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NEW HARMSWORTH SELF-EDUCATOR

EDITED BY ARTHUR MEE

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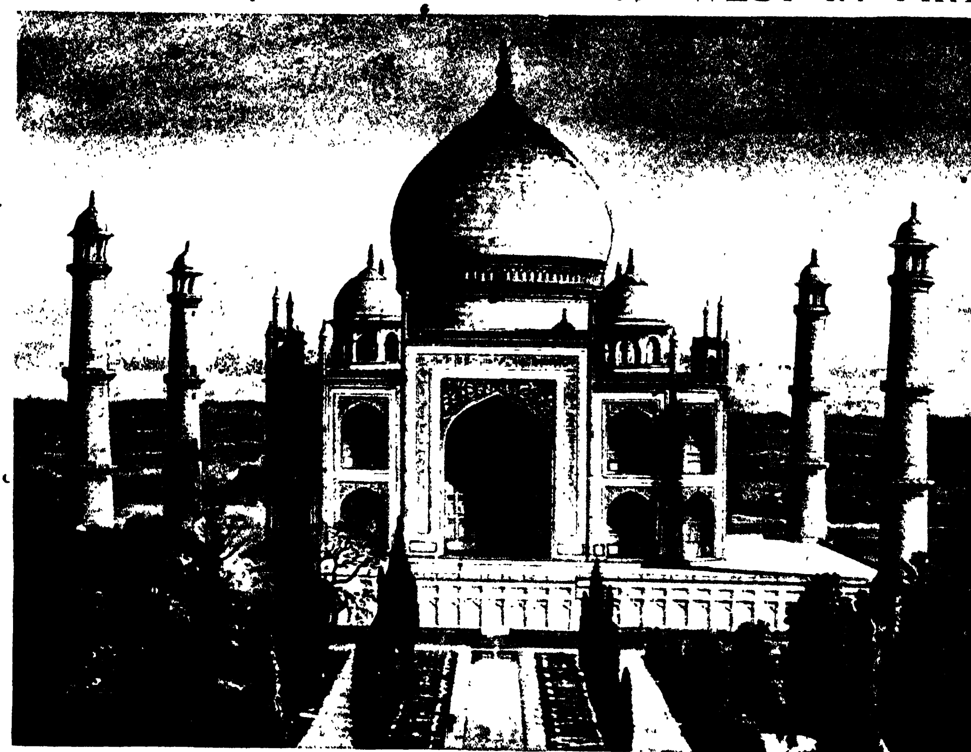
THE MEETING OF EAST AND WEST IN ART



THE MOST BEAUTIFUL BUILDING IN THE EASTERN WORLD—THE TAJ MAHAL, AGRA

THE MOST BEAUTIFUL BUILDING IN THE WESTERN WORLD—ST. MARK'S, VENICE

FACING PAGE 826

The Co-operation of Husband and Wife. Early Marriages. The Necessity for a Large Field of Common Interest.

MARRIAGE AND A MAN'S SUCCESS

If a man's marriage is to be a direct aid to success in life it must give a freer scope to his individuality than would otherwise be possible; for all true success depends primarily on a free play of intellect, energy, and character in the midst of suitable surroundings. What the man *does* depends on what he is, and on the circumstances around him that allow him to bring into full use such forces as his will, intelligence, knowledge, experience, and charm. Marriage as an aid to a man's success therefore resolves itself into the question: How can it affect a husband's career so that he makes the best of himself?

Only in doing that can he truly attain success. Accumulation of money, the vulgar test of success, may be accomplished by the meanest of mankind. The crucial question, in weighing a success, is: What has this man done with *himself?*

It must suffice that four ways are illustrated in which a wife may be an enormous help to her husband—in one, or more, or all of them—and so enable him to make more of himself than would be possible without her co-operation. Let us consider them for a minute or two without any attempt to arrange them in order of importance.

First, then, marriage may be a fine stimulus. Not only does love nerve a man for exertion, but it is quite possible a wife may have certain elements of character that the husband lacks, and so may contribute just the heartening and strengthening he needs. From her he may catch the energy and persistence without which he would become slack.

Again, a wife can often do more than a man towards securing for both such a place in society as conduces to success. While it is true that many forms of success are independent of social surroundings, some are not, and a woman often has a quicker sense than a man of what is needful to hold easily a suitable social place. In the whole region of social usage, including tact, manners, dress, address, and the fitting out of a man to best advantage as far as appearances go, a wife is frequently a shrewd observer and manager, and indeed is most useful where the husband, perhaps because of force and self-will, has a contempt for what he regards as little things. She is a mistress of the suitable where he would fail.

Further, and more essential, she will relieve him of a considerable share of establishment duties that would be hampering to him, and that she is more competent to fulfil. She should be able to stand between him and the tradesman. Within limits agreed upon, she is the chancellor of the exchequer. As a bargainer and manager the average practical woman is perhaps superior to the average man, and can relieve him of a mass of petty business if he will give her a free hand in a sphere clearly defined as her own.

Last, it is the peculiar province of a wife to make for a man such a home as he can never hope to make by himself; to provide the place of rest and comfort that will bring refreshment and renewal after the work of his day, whatever form it may take; to surround him with the conditions under which the tenderer side of his nature will flourish; to bind him, through family love, to the great family of man as business or philosophy never can.

Without these various aids from a wife how can any man be making the best of himself? But the doubter may object, what of the other case where the wife gives no such assistance? Let it be granted that the perfect marriage is the straightest way to the perfect life, but what relation has marriage to success when the wife is not an inspiration, but a drag; when she is not a social recommendation, but becomes the more out of place in proportion to her husband's success; not a wise helpmate, but an irresponsible squanderer; not a skilful home-maker, but one who causes the domestic circle to be a new trial and discipline added to life's hard round? The answer to these questions is clear. Though marriage may have a direct and enormous bearing on success, it all depends on the woman chosen. It may be a losing handi-

cap. This being so, if our discussion of marriage is practical it must turn on the choice of a wife.

Here, before beginning with advice, a root objection to all advice may be noticed. It may be doubted whether anybody ever takes advice about marriage. Each goes his own way, probably under the influence of illusions, but resentful of interference; and moreover, the infinite variety of characters and of circumstances makes the application of general rules unsafe. What might be true for a poor man is less true for one better off, and perhaps untrue for the rich. For example, the saying "A man must ask his wife if he may live" is true to the uttermost of the labourer, but not of those who have surplus wealth. Happiness and success in marriage depend, further, upon a very delicate balance of qualities that outside advisers cannot know, or greatly affect. Still, though advice may be less effective than those who give it could wish, it must not be wholly abandoned, for it may lead some to think out for themselves beforehand the salient conditions of married life, and help them to make the best of their possibilities.

Approaching marriage first from the standpoint of youth, some very interesting questions arise. Are youthful engagements wise? Is it well to marry someone known from childhood? Something may be said for the steadying effect of an early engagement, but such associations are often formed, and even marriages precipitated, long before young people know themselves, or each other, or the world. How can preparations for a marriage be wisely made before a man knows what position in life he is likely to fill, and therefore before he can judge whether a particular woman is suited for accompanying him through his ultimate career? Marrying someone known from childhood has the probable advantage of full knowledge of the wife's family history, but it is likely to mean a marriage into exactly the same set that the young man started from. That may be decidedly conducive to success in some cases, as it may be conducive to failure in other cases.

Suppose, for example, a man knows he will be a farmer all his life, and can map his career in a fairly complete way, somewhere between the farming of 150 acres and 400 acres, then he may know very well which of the young people among his farmerly acquaintances is likely to make him a genuine helpmeet. If he travels farther he will in all probability fare worse. But the young man who is going forth into the world to conquer an unknown future, and who will never return to the harbour of his childhood after being launched on the broad ocean of life, except to pay a visit now and then, had much better start free from the tie of an early engagement.

The great reason against an early engagement, and an early marriage, in the case of a man who is going to make his life a success is that in a successful marriage the husband and wife must progress together. If one is left behind, in taste and competence for position, there may be loyalty in the union but there cannot be complete success.

Provided a man knows assuredly what his place in life is likely to be, and that the woman of his early choice is certain to accompany him always as his equal, there are many advantages in a fairly early marriage between people of approximately equal ages who have had time to prepare pecuniarily for the responsibilities of a home. It brings the stress of family life at the age when it can be most buoyantly borne. It enables the man and the woman to face and fight the whole of life's battle together. And it gives the best hope of quiet enjoyment of the later stage of the long comradeship.

Suppose, then, the suitable marriage made, what are the essentials and tests of its success? One of the greatest essentials is to have many ideals in common—a large intellectual and moral meeting-ground where there is a fusion of opinion, hope, and effort. Often religion provides such a ground; or that religion of human helpfulness which is so much larger and more generous than the religion of the theologies; or the world of books may be a happy meeting-place. Similarity of outlook on life is a great bond, and an overwhelmingly favourable feature may be found in the possession of a harmonious conception of humour. But while a deep sense of life's incongruities has a rare effect in smoothing difficulties of temperament, which disappear the moment the two people smile together, the marriage of people who have antagonistic conceptions of humour is peculiarly fatal. No order of God's creatures becomes quite so intolerable as the industriously funny man who is not funny.

The mutual attitude which tends most to happiness, the first step to success, is that which always hastens to give the first place to the interests of the other, and is never jealous of the dignity due to self. But however ready husband or wife may be to lose personal thoughts in thought for the pleasure of the other, that self-surrender cannot be applied instinctively to opinion as it may be to feeling. Personal interest may vanish, but judgment will not be so easily disposed of. Suppose one thinks, in all seriousness, that a certain course is wise, and another that it is unwise, then it is not kindness to give way. The need for a sleepless sensibility arises when such differences tenacious judgments should not waive their point, and harmony of the mind reign as well as harmony of the affections.

But, after all, no wise rules or thought-out schemes of behaviour will conquer the disabilities of such close association as marriage must bring, though they may help. The only final accommodator between husband and wife in the constant interplay of their personalities is—love. That alone adds content to ease of working in the home; and to content adds zest. That alone makes marriage not a wise convenience but a poem. The real tests of a marriage are whether the joint life constitutes the central pleasure of life, and whether the pair grow dearer to each other the longer life lasts.

HOME—FROM THE PAINTING BY T. B. KENNINGTON, reproduced from the engraving by Messrs. Baumann & Co

present themselves, as sooner or later they must. For one must give way in judgment, and yet give way without surrendering personality. How is it to be done?

The secret of wise difference in opinion between man and wife, with mutual surrender, without disunion, is to be found in a common-sense division of life's affairs into those on which the wifely view should predominate and those on which the husband presumably knows best. In each respective sphere the less experienced, while expressing a personal preference, if need be, gives way to the other's judgment, and with chivalry and courtesy and humour in play there is no reason why the most

The arrival of children is a complication in the success of a marriage, to which inadequate attention is usually given. Parents who have never failed in their loving loyalty to each other before they had children sometimes fail under the new test of caring sufficiently both for children and husband, or for children and wife. Everything must give way to the child—an attitude that is not just to the parents and becomes, when persisted in, harmful in the highest degree to the child. Then, again, it often happens that, though one of the parents is wise and capable in the upbringing of children, the other has not that peculiar power, and

the result is that, if the less competent parent does not admit the facts, and in a large degree surrender the upbringing of the children to the parent who has the gift of training, there will be harmful disunion, and possibly a ruined family. To be a really good mother or father is in truth a sheer gift. If neither parent has it, the children are better reared away from home; if one has it, that one should be left in command by the self-controlled common sense of the other. The part of an affectionate and admiring onlooker is quite sufficient for the parent who has not the knack of training children. No marriage can be counted as contributing to true success in life that fails with the training of its children.

It may be objected that we are taking too high a standard of marital feeling, and that many successful marriages, both as marriages and in their bearing on the husband's life-work, have not begun with any great show of sentiment. That is a feature which cannot be denied. There are, indeed, countries where the married state is rarely the outcome of strong personal devotion. It is not far removed from a business arrangement. That is so in France in a very considerable percentage of instances. And yet the level of married happiness in France is not low. How does that come about?

The explanation is one that deserves attention from those who approach marriage under full sail before the somewhat gusty winds of sentiment. The fact is that in a French marriage the partners are not animated by the degree of affection that becomes exacting and over-sensitive, and are therefore prepared to give more common-sense consideration to the wife, or husband, than more romantic feelings sometimes suggest. They do not expect too much from marriage, and so do not court disappointment, and in the end they grow into a husbandly and wifely affection that is as real as the mature love left by the Englishman's more impulsive wooing. The French people settle down to a partnership of mutual help which compares with the best type of English marriage, and surpasses in hopefulness the prospects of those whose chief object in marriage is to give and to enjoy what is called "a good time." This momentary ideal shuts out the long after-life when, in any real marriage, duty must be the dominating motive of both husband and wife—a motive present from the first in the less romantic French marriage.

Successful marriages exist in a variety that is not allowed for by those who judge it only from the view-point of a youthful lover's sentiments, though that is an aspect which no one should undervalue. It is quite possible, for example, for a marriage to be happy and real, with great usefulness, when almost everything that would be laid down in any set of advisory rules is set at defiance, as where a husband and wife go separate ways, with different aims and ideals, and yet are in a sense truly united by a devoted attachment. One of the curiosities of the married state is that some of the most successful of all marriages have been entered into between people whose intellectual reciprocity was not specially active.

The most outstanding examples of this happiness in diversity were once offered to public observation by two great rival English political leaders, Lord Beaconsfield and Mr. Gladstone. Each of them was most happily married, yet there were many points on which a strange incongruity existed between Beaconsfield and his wife; while Mrs. Gladstone illustrated almost to perfection the possibility of a simple, loving, and watchful woman proving herself an indispensable helpmeet to a man of wonderful range of interest and of mental power, without even remotely approaching him on his own plane of intellectuality. Mrs. Gladstone was a sweet, gracious, homely minister of domesticity, and she was all a woman ought to be to her grateful husband, while to her he was an oracle whose word was very truth, whether it was within or beyond her range of thought.

The theorist would probably have given Mr. Gladstone a wife of quite a different type; yet their union, lived out in sight of the public, seemed almost to give a fresh consecration to marriage. Such an experience shows that to the man of greatest resources quite a simple marriage union may be an incalculable furtherance of success, while the less able a man is, so long as he is capable of keeping himself and a wife in reasonable comfort, the more he is likely to find an advantage in joint service through life with a suitable woman. The strong man may stand alone, though it is better not; the less strong is doubly weak without a woman's partnership.

JOHN DERRY

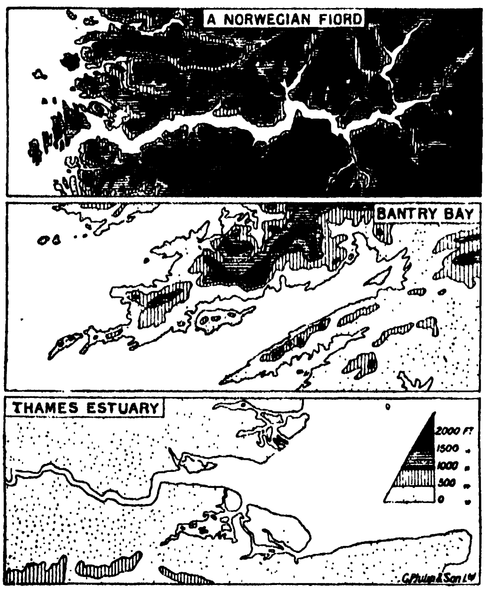
Position, Form, Structure, and Climatic Conditions of our Islands. Vegetable, Animal, and Mineral Productions.

OUR OWN COUNTRY

The British Archipelago. Britain, or the British Isles, consists of the large island of Great Britain—divided into Scotland in the north, England and Wales in the south—and the smaller island of Ireland lying to the west. The least distance between the Scottish and Irish coasts is only about 14 miles, the shortest regular service is 35 miles, and the mail routes to Kingstown, and to Rosslare about 60 miles. Lying off these two main islands are many smaller ones, of which notice the Orkneys and Shetlands, lying north of the extreme north-east of Scotland, the Hebrides and other islands fringing its west coast, the Isle of Man in the middle of the Irish Sea, Anglesey, separated from Wales by the narrow Menai Strait, the Scilly Isles off the extreme south-west of England, and the Isle of Wight off the South Coast, near the middle, separated from the mainland by the narrow straits of the Solent and Spithead. The Channel Islands, near French waters, are politically, though not geographically, part of Britain. Altogether there are over 5,000 islands in the British Archipelago, many of which are mere uninhabited rocks.

The British Seas. West of the British Isles is the Atlantic Ocean, separating them from the New World by nearly 2,000 miles of ocean. Ireland, separated from Great Britain by the shallow Irish Sea, which is entered from the Atlantic by the North Channel in the north and by St. George's Channel in the south, lies like a breakwater off the central portion of the larger island, shielding half of its western coast from the full force of the Atlantic storms. The eastern shores of Great Britain are washed by the shallow North Sea, which opens by the narrow strait of Dover into the English Channel. These shallow seas are unfortunately dangerous to navigation owing to the numerous sunken rocks and sandbanks, of which the Goodwin Sands have perhaps the most infamous reputation. The Dogger Bank, covered by shallow seas, about 80 miles off the Yorkshire coast, is a rich fishing ground, much visited by the many fishing fleets from the surrounding countries of the North Sea.

The British Coasts. The Atlantic coasts differ considerably in character from those of the more confined seas. The former are, as a rule, rugged, mountainous, and deeply cut into fiords and islands. Here the sea has drowned the lower ends of the valleys, partly probably through the gradual sinking of the highland areas. These deep inlets are called loughs in Ireland, and firths or lochs in Scotland. A glance at the map shows how characteristic they are of the Atlantic coasts, not merely of Britain, but also of Norway. The coasts surrounding the confined seas, on the other hand, are, as we should expect, generally low, and often sandy, with high cliffs only where the highlands come down to the sea. The famous white cliffs of the South Coast, dear to the wanderer homeward bound, are the edge of the low chalk heights of southern England. The rivers flowing to the shallow seas from long estuaries are quite different in scenery and mode of formation from the fiords of the Atlantic coast [63], though on a map they look very similar.



63. BRITISH COASTS AND A NORWEGIAN FIORD
A COMPARISON

The coasts, therefore, both of the Atlantic and of the shallow seas, are deeply penetrated by water, so much so that no place in the British Isles is 100 miles from the nearest sea [64]. The deep estuaries wind far into the land, permitting ocean-going ships to discharge their goods almost in the heart of the country.

There is a remarkable though accidental symmetry in the situation of some of the more important of these openings, which are arranged, as it were, in pairs. In the South of Scotland the head of the Firth of Clyde on the west is only about 25 miles distant from the head of the Firth of Forth on the east. Similar pairs are the Mersey and Humber, about 80 miles apart, and the Severn and Thames, 100 miles apart. Communication between the eastern and western seas by ship canal would consequently not be a very difficult matter.

64. THE BRITISH ISLES, SHOWING THE ACCESSIBILITY OF THE INTERIOR PORTIONS TO THE SEA.

Position of Britain in Relation to the Continent. Britain is a fragment of the mainland of Europe, cut off from France, her nearest Continental neighbour, by the submergence of the Calais-Dover isthmus. The shores of France are clearly seen from Dover, which is only 22 miles from Calais. Note also (1) that the estuary of the Itchin, or Southampton Water, is opposite the estuary of the Seine in northern France, from which it is just over 100 miles distant; (2) that the estuaries of the Thames and Stour on the east coast of England are exactly opposite the mouths of the Rhine on the opposite coast of the North Sea, at approximately the same distance; and (3) that the estuary of the Humber further north on the east coast of Britain is opposite the estuary of the Elbe in Germany, though in this case the distance is not far under 400 miles. Britain, therefore, is insulated, but not isolated, as has been

wittily said. Her island position protects her against invasion by land, and saves her many costly military burdens. On the other hand, the warder seas are not too broad for her to keep in touch with the march of civilisation and ideas in Europe.

Bridging the Seas. The estuaries which help communication by sea impede it by land. Some of these have therefore been bridged, and others tunnelled. In Scotland the estuary of the Tay is bridged at Dundee by the Tay Bridge, over two miles long. Further south the towering Forth Bridge, 1½ miles long, unites the opposite shores of the Forth. The Menai Bridge connects Anglesey with the mainland. The Severn and Thames are both bridged and tunnelled. Various schemes are suggested for uniting the two sides of the English Channel. Of these a channel ferry is probably the most feasible.

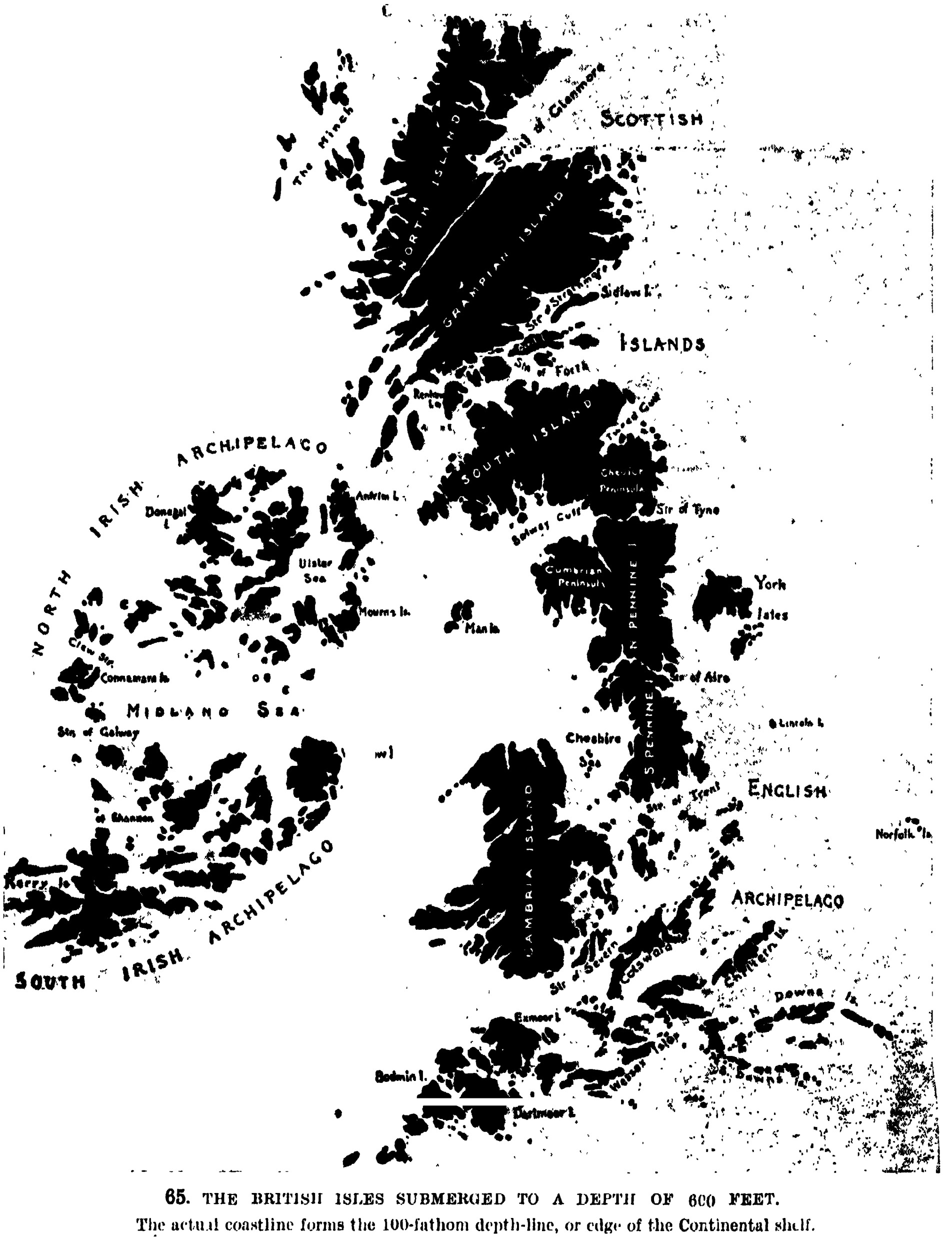
An Imaginary Map of Britain. If the sea round the British Isles were to rise 600 feet, the present islands of Great Britain and Ireland would be transformed into an archipelago of many islands, large and small, most of them very irregular in surface. These islands would represent those parts of Britain at present more than 600 feet above sea-level. The seas separating them would represent the parts at present less than 600 feet below sea-level. Fig. 67 shows what the new map of the British Isles would look like. Beginning in the north we should have, where Scotland used to be, two large islands separated by a long, very narrow strait. These would represent the North-western and Grampian Highlands respectively, and might be called North Island and Grampian Island. The long, narrow strait between—a mere silver streak—would represent Glenmore—the Great Glen—the long, narrow valley at present filled by a chain of lakes connected by the Caledonian Canal [65]. South of Grampian Island a stretch of broader sea, in places nearly 50 miles wide, covering the broad valley which has been riven by movements of the earth's crust between the mountains on either side, would be studded by islands representing the Campsie Fells, the Ochils, and others. In the east a long, narrow island, representing the Sidlaw Hills, would be separated from Grampian Island by a broadish strait representing the present vale of Strathmore. Still further south the mountains of southern Scotland, the Southern Uplands, would form a large, irregular island, separated from islands representing the northern uplands of England, by a narrow strait similar to that of Glenmore, and representing the present Eden and Tyne valleys.

Imaginary Islands. The northernmost of these English islands, North Pennine Island, representing the mountains of Cumberland and Westmorland, and the Northern Pennines, would be cut by deep arms of the sea, representing the Eden and Lune valleys. An extremely narrow strait, corresponding to the valley of the Aire, would separate North from South Pennine Island. Off these, to the east, separated by a broad strait covering the present vale of York, would lie a group of islands representing the Yorkshire Moors and Wolds, while off the south-west would be a large compact island, representing the Cambrian Highlands of Wales, separated from the South Pennine Island by a broad strait covering the present counties of Lancashire and Cheshire. South of the Island of Cambria, and separated from it by seas somewhat broader than the present Bristol Channel, would rise islands representing Exmoor, Dartmoor, Bodmin Moor, and other heights of Devon and Cornwall.

Eastern Heights. The islands in the seas to the east of these islands—east of a line drawn on our present maps from the mouth of the Exe in Devon to the mouth of the Tees in Northumberland—would be small and far apart; while east of a line drawn from the head of the Humber estuary to the head of the Thames estuary solitary islets would represent the hills of Norfolk. Most of the islands of what we may call the English Archipelago would lie in roughly parallel lines, running from south-west to north-east. The most northerly of these chains of islands would represent the heights, often rising steeply from the plain, which separate the basin of the Severn to the west from that of the Thames to the east, the highest being the Mendip Hills of Somerset, and the Cotswolds of Gloucestershire. The next chain, with their chalk cliffs, would represent the chalk heights of Dorset and Wilts, the Chiltern Hills, and the heights of Bedfordshire and Cambridgeshire, while many of the straits between them would correspond with the valleys of the Thames and its tributaries. A crescent-shaped group of small islands still further south, also with chalk cliffs, would represent the present North and South Downs.

In Ireland we should have two archipelagoes of islands of no great size, separated from each other by a Midland Sea at least 60 miles wide, unbroken by islands except in the west. The Northern Archipelago would include the mountains of Ulster and Northern Connaught, the Midland Sea would represent the midland plain, of which a line drawn from Dublin Bay to Galway Bay is approximately the southern boundary, while the islands of the Southern Archipelago would represent the mountains of Munster and South Leinster.

The Actual Map of Britain. Comparing this map with the present relief map of Britain we see that Great Britain, the larger island, consists of two very different portions divided from each other by a diagonal line running from south-west to north-east. North and west of this Exe-Tees line lies a highland region, with few lowlands. South and east of the Exe-Tees line is a lowland region, with few highlands. The highland region consists of older, harder rocks, and is related in structure to the mountains of Scandinavia. The lowland region is formed of younger, softer rocks, which have been worn away over a large part of its area, leaving the three lines of heights already mentioned. This part of Great Britain is akin



65. THE BRITISH ISLES SUBMERGED TO A DEPTH OF 600 FEET.
The actual coastline forms the 100-fathom depth-line, or edge of the Continental shelf.

to the neighbouring mainland, and forms part of the European lowland. Ireland is a plain diversified by heights, and not a highland region divisified by lowlands.

The Lowlands of Scotland. We must now notice more in detail the position of the lowlands, for in these the population of the country is concentrated. Observe how the north-west of Scotland and the adjacent islands are almost entirely highland. There are lowlands in Lewis, the largest island of the Hebrides, in Islay, Arran, and others; but on the west coast of the mainland, as far south as the Firth of Clyde, the mountains come right down to the sea. In the east are the small lowland of Caithness in the far north and a narrow coastal lowland which runs almost unbroken south round the Moray Firth, and widens in Elgin and Banff to the lowland of North Aberdeenshire, with its group of busy towns. The area of these small lowlands is inconsiderable compared with the great compact mass of the highlands. In such a country, therefore, consider the value of the natural rift of Glenmore, which affords a unique means of communication between east and west. Equally clear is the importance of the Tay valley, which connects the Highlands with the

Midland Plain of Scotland, where the population of the country is concentrated. In this plain, which extends, broken by numerous heights, from the estuary of the Clyde to the estuary of the Forth, lie, as we should expect, almost all the important towns of the country.

To the south of it the Southern Uplands widen out again, with coastal lowlands in the east and west. The eastern lowland narrows abruptly where first the Pentlands and then the Lammermuirs approach the sea, making Edinburgh, at the base of the Pentlands, the key of Scotland, and Dunbar, at the base of the Lammermuirs, the key of Edinburgh. The Cheviot Hills connect the Southern Uplands with the Northern Uplands of England. Throughout this region the lowlands are chiefly associated with the river valleys. Notice the importance of these means of communication. The valleys of Annan and Clyde provide a direct route to the north; the Tweed valley—the only populous part of the southern uplands—opens up the country from east to west; and a route to the south is afforded by the valleys of the Teviot, a tributary of the Tweed, and of the Liddel, flowing to Solway Firth.

The Lowlands of England and Wales. The Tyne valley—or the Tyne gap, as it is often called—is a route between east and west, between the Cheviots and the Pennines. Notice also the Eden lowland in the west, driven like a wedge between the Pennines and the Cumbrian mountains of Cumberland and Westmorland, and its importance as a route. The lowland of York, east of the Pennines, is drained by the Ouse and its tributaries, one of which, the Aire, divides the Northern from the Southern Pennines. The Aire gap, like the Tyne gap, is all important as a route between the lowlands east and west of the Pennines. West of the Southern Pennines, the Cheshire plain between the Pennines and the Welsh mountains opens from the central plain to the Irish Sea exactly opposite the Midland Plain of Ireland. It is consequently the most direct route between the capital of England and the capital of Ireland. Wales has a coastal lowland continuous with the Cheshire plain, narrow in the north and west, but broadening out in the south along the northern shores of the Bristol Channel. Towns and routes in Wales are chiefly in this coastal lowland and the valleys opening to it. The southern lowland of Wales opens by the Severn valley to the plain of England, the northern part of which is drained by the Trent, flowing to the Humber, and by a number of rivers flowing to the Wash, of which the Great Ouse may be noted. The southern portion of the plain, which is broken by numerous heights, is drained by the Thames and its tributaries, and by smaller rivers flowing to the North Sea and the English Channel.

The Lowlands of Ireland. In Ireland the Midland Plain is the chief lowland, running east and west across the country. The other lowlands run for the most part north and south, following the direction of the rivers. In the north the lowlands of the Foyle and Erne separate the mountains of Donegal and Sligo on the west from the central heights. Further east, between these and the Antrim and Mourne mountains, are the lowlands drained by the Blackwater and the Bann. In the west the Shannon, a river of the plain, cuts its way between the mountains of Tipperary and those of Galway and Clare, much as the Thames has done across the chalk heights of southern England. Look out in the map the lowlands of the Blackwater, east of the Kerry mountains of southern Ireland, the extensive lowlands drained by the Barrow and its tributaries, which separate the central heights of southern Ireland from the Wicklow mountains, and the lowlands south of these, drained by the Slaney.

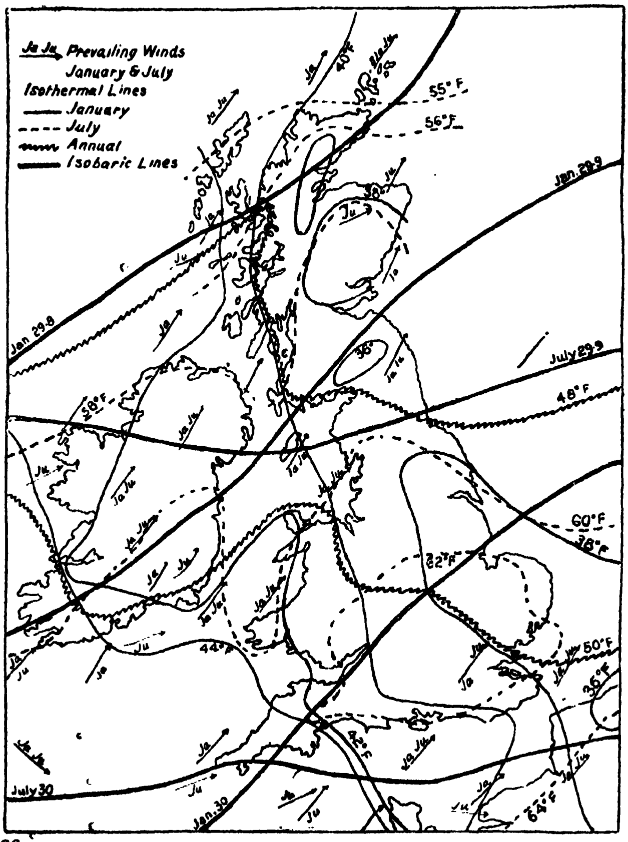
Climate of the British Isles. Our climate is greatly influenced by the proximity of all parts of our islands to the sea, a circumstance which makes our winters mild and our summers cool. The average, or mean annual temperature of the lowlands of England and Ireland is over 48° F., while in the Lower Thames valley, round the south coast of England, and in the lowlands of Cornwall and Devon, it is over 50° F. The January and July isotherms—*i.e.*, lines connecting places of the same average temperature in summer and winter respectively—remind us in many ways of the corresponding isotherms for the Continent [66]. In January the lines run, on the whole, north and south, independently, that is, of the lines of latitude; in July they run, on the whole, east and west.

Winter Temperature. Taking the British isotherms for January, we notice at once the remarkable differences between east and west. The line for 44° F. cuts the extreme west of Southern Ireland and Cornwall. These parts of our islands are 6° warmer in winter than the coldest parts of the east coast of Great Britain. The line for 42° is, on the whole, parallel, but it takes an upward bend over the St. George's Channel, for the sea is warmer than the land in winter. The rest of Ireland has a temperature of 40°, but in Great Britain the only parts which are equally warm are the extreme west of Scotland, Wales, and that small part of England which lies west of a line drawn from the head of the Bristol Channel to Southampton Water. The rest of Great Britain has a January temperature of under 40°. The coldest parts everywhere when height is left out of account, are all in the east, with a temperature of 38° or under. Notice that the eastern counties, from the Humber to the Thames, are as cold as the counties round the Moray Firth, although they are much further south. The extreme north-west of Scotland is warmer than the extreme south-east of England. This shows that the distribution of winter temperature is largely independent of latitude. The all-important factor is the prevalence of westerly or south-westerly winds, which have been warmed by passing over the surface of the Atlantic Ocean. They reach our western shores as warm winds, but as they pass east over the land they gradually become cooled by contact with its cold surface. Hence the

eastern parts of the British islands are markedly colder than the western parts.

Summer Temperature. In summer the case is reversed. The Lower Thames basin, which was one of the coldest regions in January, is the hottest part of Britain in July, with a temperature of 64°. The rest of the English plain, except round the coast, has a temperature of 62°. The line for 60° includes the south-eastern corner of Ireland, the whole of Wales, and most of northern England. The line of 58° almost coincides with the north coast of Ireland, and follows the west coast of Scotland for a considerable distance, curving gradually inland to the east coast near Aberdeen. North of this line the lines for 56° and 55° are nearly parallel to each other. Only the Orkneys and Shetlands have a summer temperature below 55° F. In summer, therefore, the east is hotter than the west, but the south is hotter than the north. The relative coolness of the west is, of course, explained by the influence of the Atlantic winds, but we see that their influence is much less marked than in winter, when they blow more strongly and steadily.

Advantages of the British Climate. Our great climatic advantage is our mild winter. Britain lies far west of the isotherm of 32° F., the freezing point. Except on the highest hills, even in the coldest parts of our islands protracted frosts seldom occur, and the check to vegetation is not very considerable. Our ports are ice-free all the year round, and our inland waterways seldom frozen. Our summers, though never oppressively hot, are warm enough—except in the extreme north—to bring wheat and many fruits to perfection.



66. THE CLIMATE OF THE BRITISH ISLES—THE ISOTHERMS, ISOBARS, AND THE DIRECTION OF THE PREVAILING WINDS.

Distribution of Rain. The proximity of the Atlantic influences our rainfall no less than our summer heat and our winter cold. The winds which blow from that ocean—and they blow on an average for two out of three days—are loaded with moisture when they reach our western shores. As they blow all the year round, we have rain all the year round; but they are strongest and steadiest in winter, which is our wettest season. As we should expect, the west is wetter than the east [67]. Had the highlands of Britain lain to the east instead of to the west, the difference in the rainfall of east and west would have been much less marked than at present. As it is, the highlands lie full in the track of the rainy winds, which part with most of their moisture on the windward slopes. The wettest parts of the British Isles are the Connemara and Kerry mountains in the west of Ireland, which have over 60 in. of rain in a year, the highlands of Scotland, and the mountains of Cumberland, Wales, and Cornwall. The plain of England has a rainfall of under 30 inches.

It is interesting to compare the rainfall map of Britain with the temperature map for July. We see that the regions with the hottest summers are, on the whole, the driest parts of the country, while the wettest districts have the coolest summers. The effect of this on agriculture is very important. If the summers in the English plain were wet, neither cereals, hay, nor fruit would come to perfection. The western highlands intercept just enough of the rain to provide almost ideal agricultural conditions in the eastern lowlands. Had the lowlands lain in the west, Great Britain would have been in the main a pastoral country, with a less dense population than at present.

Storms, Cyclones, and Anticyclones. Destructive storms frequently visit our coasts, especially in autumn and winter. The first sign of their approach is generally the fall of the barometer. This shows a diminution of atmospheric pressure when an area of low pressure, or an atmospheric depression, as it is called, is moving towards our islands. These

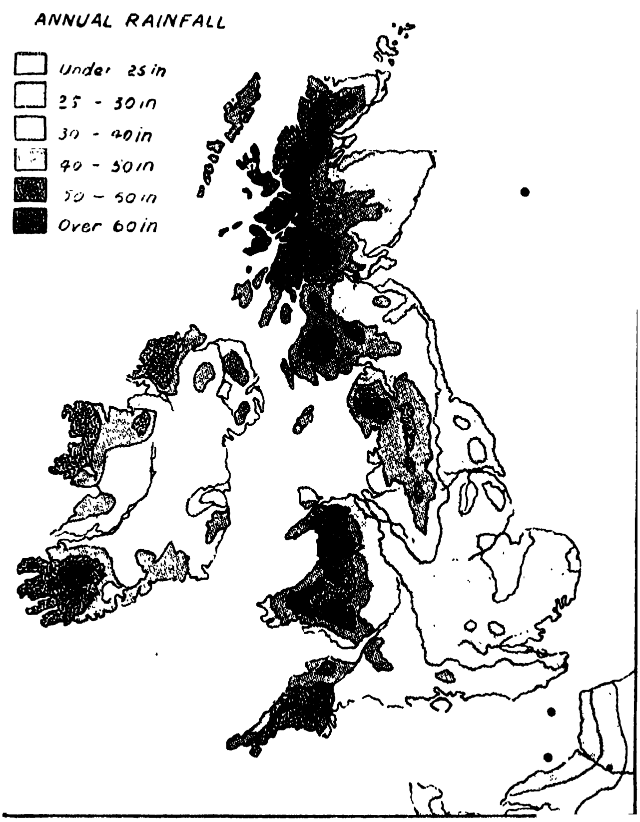
depressions usually come from the west—very rarely, indeed, from the opposite direction. As the depression moves onward, air is drawn in from all sides from regions of the atmosphere which are at a higher pressure, producing violent gales, blowing from all directions spirally inwards to the centre of the low-pressure area, which itself remains calm. If the depression is a large one, these gales may last for several days, gradually decreasing in violence as the atmospheric pressure is equalised. Such a moving system of winds blowing inward toward a calm centre is called a *cyclone.*

In winter, when the temperature conditions on which the distribution of atmospheric pressure partly depends are most unequal over the Northern Hemisphere, cyclone after cyclone may occur for many weeks. When the track of the centre of the cyclone lies north of our islands, the winds over the British Isles blow from the south or west, and the weather, though wet and stormy, is mild. If the storm centre is moving south of our islands, we are swept by icy gales from the north or east.

In an *anticyclone* the conditions are reversed. The winds then blow outwards from a calm centre of high pressure toward regions of lower pressure. When anticyclones occur in winter our weather is usually fine, but intensely cold, owing to the loss of heat by radiation in the calm, cloudless nights; on the other hand, when they occur in summer, our weather is generally calm, warm, and hazy.

Vegetation. Britain lies naturally in the temperate forest area. The whole of the lowlands were once covered with dense forests, composed in the south of oak, elm, and beech, mixed with conifers in the north. Traces of this vanished mantle of forest remain in such patches as Epping Forest or the Forest of Dean, and in such names as Ettrick Forest or Sherwood Forest. Today only about four per cent. of Britain is woodland; 50 per cent. is in crops or grass; 30 per cent. is grazing land, and the remainder consists of mountains, water, and roads. Agricultural land is found chiefly in England and Wales, of which three-quarters and three-fifths respectively are under cultivation. In Scotland and Ireland only about one-quarter is cultivated, and grazing is much more important, employing one-half of the total acreage of both. In England less than one-tenth is grazing land, and in Wales only one-quarter serves this purpose. Taking Great Britain only, and examining these figures, we should conclude that the relation between agricultural and grazing land depends chiefly on the distribution of relief, the lowlands being agricultural and the highlands pastoral. And this is quite true. It is true, however, largely because the highlands are wetter, as we may see by comparing the figures for Scotland and Ireland, which differ greatly in relief. For the same reason, we find a difference even in the lowlands of England, agriculture being more important in the drier east than it can possibly be in the wetter west country.

Soils. The distribution of agriculture no doubt depends also on soil, and this again on the character of the underlying rocks. We saw that the highlands of Britain consist of old and very hard rocks, which weather slowly, forming but little soil, most of which the rivers carry down to the plains. Where the rocks are softer the soil is much deeper, and of a very mixed character, consisting not merely of the waste of the rocks immediately below, but also of rock-waste of many different kinds brought down by rivers and by the long-vanished glaciers which once covered a great part of our islands. [See GEOLOGY: The "Ice Age."] The local variations are, nevertheless, very great, and every eye detects the difference, for example, between



67. THE CLIMATE OF THE BRITISH ISLES—THE ANNUAL RAINFALL HEAVIER ON THE WEST THAN THE EAST COAST.

the white soils of the chalk districts of Sussex, or of the limestone districts of Gloucestershire, and the rich red earth of the sandstone districts of South Devon.

Chief Crops. The chief crops are cereals. Wheat and barley are grown in the south-eastern counties, and in the east of the midland plain of Scotland. Oats and barley are grown on the poorer, higher, or more northerly soils. Root crops are cultivated everywhere, but less on the best soils. Potatoes are important in the higher and wetter agricultural districts, and are the staple crop in Ireland. Hops are grown in Worcestershire and the southern counties, those of Kent being specially famous. Fruit is less grown than it should be, especially by the peasantry, who thereby miss a source of profit. Apple orchards and fruit farms are important in the southern counties, particularly in Kent, Devon, and the Severn basin. Flax is grown in the north-east of Ireland, but not so commonly as 30 years ago. Many useful crops, such as the sugar beet, are rarely grown. English agriculture, as a whole, has suffered from our land system, the lack of technical education, and the reluctance to adopt the co-operative methods which ensure success in other countries.

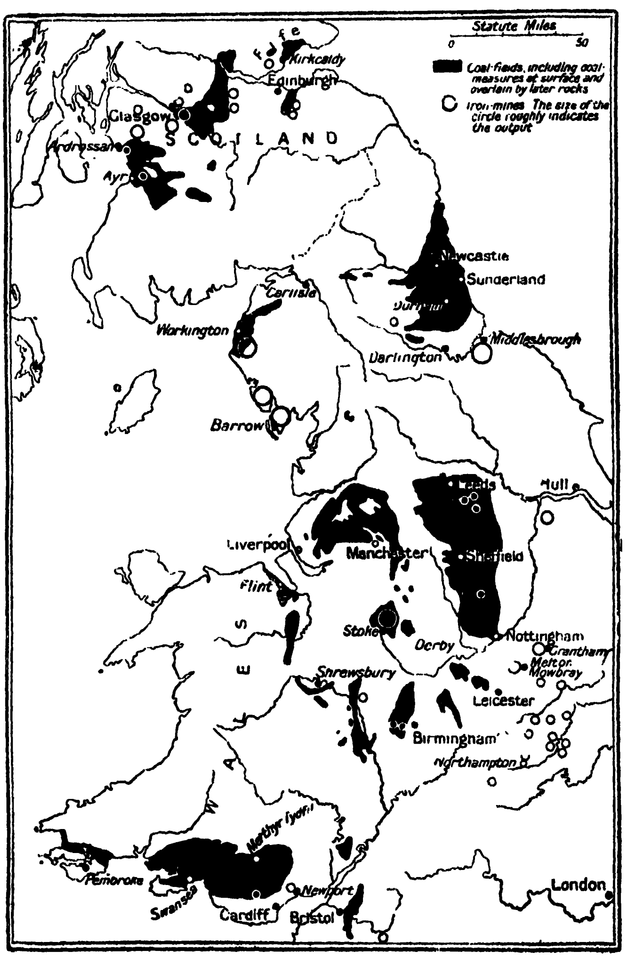
The Pasture Lands. These are of two kinds—the moist water-meadows of the lowlands of western England and Ireland, which are suitable for the finest breeds of cattle, and the poorer, less succulent pastures of the uplands or highlands, which are not rich enough for cattle, but suit sheep. Broadly speaking, cattle are fed in the lowlands and sheep on the hills.

Cattle are bred both for beef and for dairy purposes, the latter requiring the richer pasture. The Shorthorn breed is suitable for both purposes. Ayrshire cattle, and the breeds named from Jersey, Guernsey, and Alderney, are primarily dairy cattle.

In England cattle are most numerous round the western base of the Pennines—in Lancashire, Cheshire, and Staffordshire, in Leicestershire, in the Midlands, in Somerset, Devon (famous for its Devonshire cream), and Cornwall. Pembrokeshire is the chief cattle-raising county in Wales. In Scotland cattle are chiefly bred for beef, and are numerous only in the midland plain, large numbers being imported from Ireland to be fattened for the London market. In Ireland the chief grazing counties are Galway, Limerick, Meath, and Dublin. A large quantity of butter and other dairy produce is exported to England. The keeping of pigs is generally associated with dairy farming, and dairy-fed pork and bacon are highly esteemed.

Sheep Farming. English wool has been famous for centuries, and sheep farming has long been important. Sheep are kept on the hill pastures in all parts of the British Isles, but are more important in Great Britain than in Ireland. Most of the good breeds supply both mutton and wool, but more attention is paid to the quality of the wool in the east, and to the quality of the mutton in the west. The chief sheep-farming districts are the chalk downs of England, the Welsh highlands, and the southern uplands of Scotland, particularly the Tweed valley. In Ireland most sheep are found in Carlow, Wicklow, and Galway.

Horse Breeding. Horses require better pasture than sheep, and less rich pasture than cattle. They can therefore be kept in districts which are too dry for cattle. Most of the famous breeds belong to the eastern counties—York-



68. COAL AND IRON FIELDS OF GREAT BRITAIN

There are workable seams of coal in the carboniferous limestone and millstone grit of Scotland, but these areas are not shown in this map.

shire, Norfolk, Suffolk, Cambridge, and Huntingdon. In Scotland the eastern counties of Fife and Linlithgow are the most important. In Ireland, Dublin, Down, Wexford, and Louth breed most horses.

Fisheries. The shallow seas surrounding Britain, and particularly those off the east coasts, are rich in fish. The Dogger Bank, in the North Sea, is one of the richest fishing-grounds in the world, especially for cod and flat fish. The herring fishery is important round the eastern coasts of Britain, following the movements of the herring, which migrate southwards as the year advances. Pilchards are caught in the Cornish waters. The oyster fishery is important off the eastern coast of England.

Minerals and Metals. Many of the rocks which compose the crust of the earth are of use; granite, for instance, is much quarried for building round Aberdeen. The various sandstones and limestones also make good building stones, and limestone is burned for lime. Slates are quarried in the mountains of Wales, Cumberland, and the north of England generally. Some rocks, like those of Caithness, are used for paving; others, like those of Portland, for cement; and new uses are frequently discovered. In recent years a quarry near Oxford has furnished material for a famous polishing soap. In the plains, clay is used for making bricks, or, if of sufficiently fine quality, for pottery. The fine decomposed granite of the south-west, called kaolin, is carried to the Potteries via the Mersey, and is used to make the finest porcelain.

Coal. Of all the products of the earth's crust coal is at present the most valuable. It is used to generate steam for motive power, and our industries depend on a cheap supply of this indispensable fuel. The coal measures lie above the oldest but below the younger rocks, and can be worked only when some accident brings them near the surface. In parts of the British Isles [68] the crust of the earth has been thrown into waves by the action of internal forces raising the highland regions. In many of these the upper layers of rocks have been worn away in the course of ages, leaving the coal measures exposed in places, so that they can be reached by boring through the surface soil. In the Pennines not merely the younger rocks but the coal measures also have disappeared from the summit. They remain on both flanks, forming the important coalfields of northern England. Coal is similarly exposed round the eastern and southern margin of the west highlands, and in some parts of the Midlands. Over most of the English plain the coal measures are buried beneath younger rocks, and cannot be worked. In Scotland the coal measures remain in the trough of the midland plain, forming coalfields which extend almost continuously from the Clyde to the Forth. Here coal is largely mined from rocks lying below the coal measures strata in which it is mainly found in England. In Ireland the coal measures have disappeared, except in a few isolated patches. Much of the country is covered with peat bogs, which supply the only available fuel.

Iron and Other Minerals. Next in importance to coal is iron [68], which occurs in many different forms. The purest quality, known as red hematite, is found in the western Pennines. The less pure, brown hematite, is abundant round the margin of the Welsh highlands, in Northamptonshire, and in Antrim. Other ores are very common in or near the principal coalfields, the most important being the black-band ironstone of Scotland, and the ores of the Cleveland hills of Yorkshire. The latter occur in the Lias rocks, which extend right across England, and have enough iron in them in other places—for example, in Northamptonshire—to be worth smelting.

Lead is worked in the southern uplands of Scotland, the Pennines, the mountains of Cumberland, Wales, and the Isle of Man, and in the Wicklow mountains of Ireland. Zinc occurs occasionally along with lead; oil shale is common round Edinburgh; salt is mined in Cheshire, Worcestershire, and Durham, and copper and tin are still worked in Cornwall.

Principal Coalfields of Britain. The coalfields of Britain fall into four groups.

GROUP ONE. The Scottish Coalfields:

1. The Ayrshire Coalfield.
2. The Central or Forth and Clyde Coalfield.
3. The Fife Coalfield.
4. The Midlothian Coalfield.

The chief manufactures on these coalfields are iron, shipbuilding, and textiles.

GROUP TWO. The Pennine Coalfields:

5. The Northumberland and Durham, associated with the iron manufacture in all its branches, including engineering and shipbuilding, and chemicals.
6. The Cumberland Coalfield, associated with iron-smelting.
7. The South Lancashire Coalfield, associated with the cotton manufacture and with iron and chemical industries.
8. The North Staffordshire Coalfield, associated with the pottery industry.
9. The York, Derby, and Nottingham Coalfield—the richest—associated with woollen, iron, and lace manufactures.

GROUP THREE. The Coalfields round the margin of the Welsh highlands:

10. The North Wales Coalfield, associated with the manufacture of salt and chemicals.
11. The Middle Severn Coalfield, associated with iron, pottery, and woollen manufactures.
12. South Wales and Forest of Dean Coalfield, chiefly engaged in smelting.

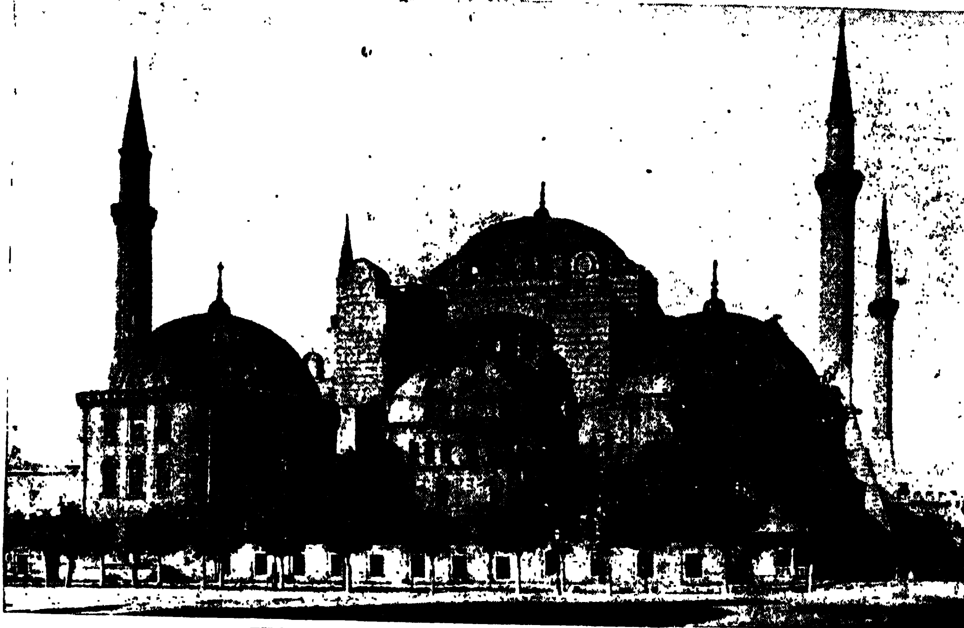
GROUP FOUR. The coalfields of the Midland Plain, surrounded by younger rocks:

13. The Midland Coalfield, associated with the iron manufacture.
14. The Bristol Coalfield, associated with the woollen manufacture of the West of England.

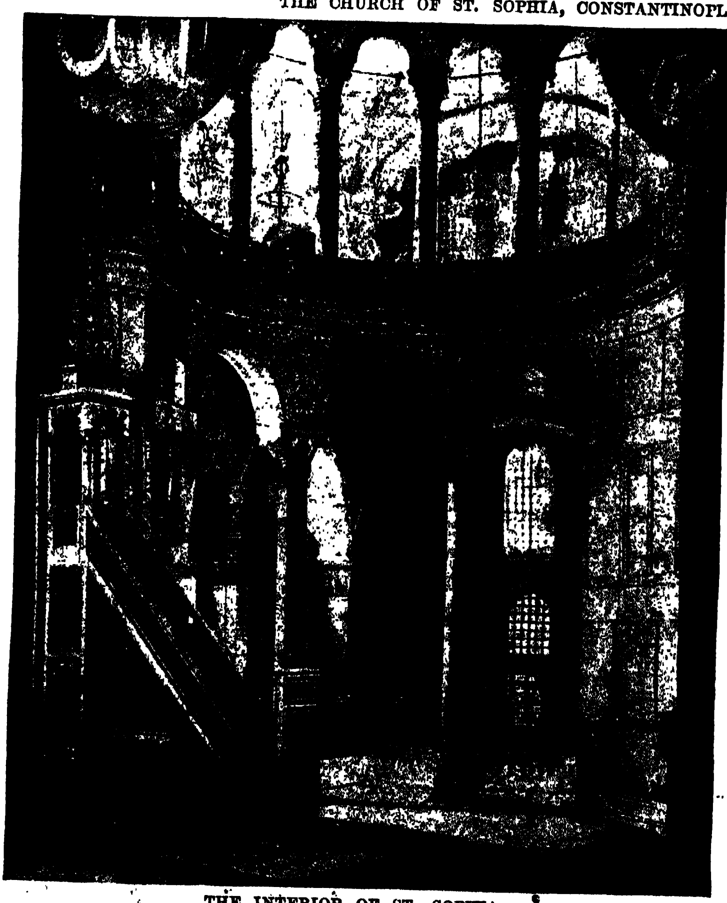
All these manufactures are more fully treated in the chapters on COMMERCIAL GEOGRAPHY.

A. J. AND F. D. HERBERTSON

THE ART TRIUMPHS OF THE "DARK AGES"



THE CHURCH OF ST. SOPHIA, CONSTANTINOPLE



THE INTERIOR OF ST. SOPHIA

THE CAMPANILE, VENICE

Early Christian Buildings and the Influence of Byzantine and Saracen Art on the Eastern Church

ART IN EARLY CHRISTIAN TIMES

EARLY Christian art is the connecting link between antique pagan and mediæval or Christian art proper. It fills the gap between the Classic and the Gothic period. It starts in the sheltering obscurity of the catacombs, whence it issues victoriously, spreading far and wide and annexing not only the material of the deserted pagan temples and halls of justice, but in many cases the very forms of construction and artistic expression.

Thus in the West, in Rome, the Pantheon, a heathen temple, was adapted for the requirements of Christian service, whilst the form of the Roman basilica was, for a time, chosen as the definite form of early Christian church buildings. Columns and other remains of Roman buildings were freely used for these new edifices, cut down if too long, or added to if too short—put together as they happened to come to hand, without regard to the style of the capitals, shafts and bases.

The basilica lent itself most readily to religious service, owing to its division into the apse at the back, which was reserved for the bishop and the priests, and the nave and aisles for the community. The altar was erected in front of the apse, under a canopy, or baldachino, supported by marble columns. A kind of triumphal arch separates it from the nave. The lofty nave is divided from the lower aisles by a colonnade on either side, which supports the clerestory wall, through the openings of which daylight floods into the interior.

The entrance gates are opposite the apse, and access is gained through an opening colonnaded court, or atrium. At times a transept was introduced which converted the plan into a Latin cross, of which the nave was the long arm. The niche-shaped apse, the walls of the triumphal arch, and sometimes the clerestory walls were richly decorated with figures of saints, either painted or in mosaic with plentiful use of gold. The most magnificent building of this type is the basilica church of St. Paul outside the walls of Rome, which was destroyed by fire in 1825, but has since been rebuilt on the original plan.

Another form of early Christian building which was derived from Roman prototypes was the circular or polygonal baptistery, which up to about the sixth century was a separate building, and which was constructed on the plan of the Roman tombs, with the one difference that the columns which divided the interior, as it were, into a circular nave and surrounding aisle had to serve an architectural function as supports to the walls carrying the dome. Characteristic examples are the church of S. Stefano Rotondo, and the baptistery of the Lateran, in Rome.

With the decline of the Western Roman Empire, Byzantium, now Constantinople, became the centre of the civilised world. The churches erected in the time of Constantine and of his immediate successors still followed the basilica plan; but in the fifth century, under Justinian, the art, and more particularly the architecture, of the Eastern Empire received a definite stamp and fully developed the tendencies which constitute the Byzantine style. Byzantine life is reflected in the painting and sculpture of the period, which soon took settled, dogmatic forms incapable of further development. In architecture, however, the general use of the dome (which was taken from the East rather than from Roman examples), and all the changes that this development carried in its train, introduced new life and new possibilities into this art.

A lofty central dome is generally connected with quite a system of smaller cupolas and half cupolas, and necessitates a circular plan instead of the rectangular nave. In order to join the cupola to the square walls, the curved triangular pendentive or spandrel has to be introduced, resting on mighty shafts. Through these devices large wall spaces were gained, which gave special opportunities for sumptuous mosaic decoration. The kernel of the Byzantine churches consisted of bricks and mortar, cased on the outside with marble, and decorated in the interior with paintings and mosaics. In fact,

whereas in Rome the dome was used in conjunction with the Greek trabeated system, and the effect depended on architectural articulation, in Byzantium the tendency was in the direction of flat surface decoration; and even the capitals, cornices, and friezes lost their clearly marked classic play of light and shade.

A FOURTH CENTURY MOSAIC OF THE VIRGIN MARY

The church of St. Sophia in Constantinople, now a Turkish mosque, with all its former glittering splendour hidden under a coat of whitewash, is the most glorious example of the full flower of the Byzantine style. The colossal building, the central dome of which has a diameter of 107 ft. and a height of 180 ft., was built by Justinian in five years (532–537), which constitutes probably a record in rapid building. Equally famous and characteristic is the church of St. Mark, in Venice, which was built about 1100 on the model of the church of the Holy Apostles, in Constantinople.

From Byzantium the new style spread to Italy and the rest of Europe, taking root first in Ravenna, where the church of San Vitale combines many Byzantine elements, such as the gallery resting on the inner octagonal colonnade, with a plan based on that of a Roman temple. In Ravenna, too, we find for the first time an independent campanile, or bell tower, which is not joined structurally with the church, but rises from the ground in cylindrical shape, crowned by an almost flat roof. In Italy these independent campanili were generally adopted in Romanesque architecture, whilst in Northern Europe the bell tower formed an integral part of the church building. The ill-fated Campanile in the square of St. Mark's, Venice, which collapsed a few years ago, but has now been rebuilt, was the most famous erection of this kind. In England the Byzantine style of architecture has never taken root, but the late Mr. Bentley's new Cathedral at Westminster presents a notable instance of a successful modern adaptation of Byzantine architecture.

In sculpture and painting also early Christian art in Rome was dependent on pagan prototypes. The subject was changed, but the manner remained the same, and the paintings in the catacombs bear a strong resemblance to the wall paintings of Pompeii. The fear of falling into the errors of pagan idolatry must have acted as a strong check to artistic activity, especially in sculpture, and, indeed, free-standing statues of the period are exceedingly scarce. In painting the danger was less obvious; it is less corporeal and better suited to the expression of spirituality. Nevertheless, the earliest paintings show few traces of that spiritual ardour which later led Christian art to its most glorious achievements.

The repugnance of the early Christians to representing divine ideas in human form led to the introduction of symbols, such as the fish, the alpha and omega, the cross, the palm branch, the vine, and the lamb. Amidst this new world of imagery are still found pagan ideas, such as Orpheus taming the beasts, and personifications of day and night, rivers and mountains.

It is quite obvious that the original significance of such subjects had been entirely lost sight of, and that a new application had been given to mythological figures. In painting, as in the

A BYZANTINE FRESCO IN THE BASILICA OF ST. VITALE, RAVENNA

THE AMBASSADORS' HALL IN THE OLD PALACE OF THE MOORISH KINGS AT SEVILLE

relief sculpture on sarcophagi, Roman art was thus perpetuated in a debased form. The artist no longer delighted in the beauty of the idealised human form, and gradually the sense of grace and pleasing proportions was lost, whilst a striving for the expression of spiritual grandeur took its place, until Byzantinism for a time veiled the offshoots of the Roman tradition, which, however, kept smouldering under the sumptuous formalism introduced from the Eastern Empire.

Gorgeous splendour was the keynote of the art that had developed in Byzantium, and found expression not only in the rich decoration of the churches, but in the very costumes, resplendent in gold and embroidery and precious stones, which had replaced the festive white garments of antiquity. A stiff, ceremonial formalism pervades everything—life as well as art.

The striving for dignity, repose, and stateliness soon prescribed certain formulas for the representation of the human figure, and certain attitudes which reflect the strictly imposed ceremonial of the Byzantine Court. The figures are unduly elongated, the faces forced into a narrow oval, with large eyes, long, narrow nose, and small chin. The expression is as serious and dignified as the general attitude, and shows no trace of emotional life. Only the miniatures of the period retain faint echoes of the antique and show traces of individuality. The subjects are the same as in early Christian art: Christ in glory, surrounded by angels, the Virgin enthroned in solemn dignity, figures of saints conventionally robed in garments that never suggest the shapes hidden underneath them, and representations of the emperor or empress in state. The mosaics in the choir of San Vitale, in Ravenna, are the finest examples extant.

In the eighth century the iconoclasts in blind fury destroyed most of the works of art of the Eastern Empire, and numerous painters, sculptors, ivory carvers, goldsmiths, and enamellers were driven from the country, and took up their abode in Western and Central Europe. In miniature painting, for instance, Byzantine ideas soon ruled everywhere but in Ireland, where an independent ornamental style had taken root. Examples of this wonderful Gaelic art are preserved in the manuscripts in the possession of the Royal Irish Academy, Dublin, and in the Book of Kells at Trinity College, Dublin.

It is scarcely too much to say that from the eighth to the tenth century the crafts of Europe—always excepting the extreme north, where Celtic ornament had become an ineradicable artistic tradition—were entirely in the hands of Byzantine workers and their followers. Their skill in ivory carving, in metal work generally, and particularly in enamelling and filigree work, in weaving and embroidering, was inimitable.

Byzantine influences, together with those of India, Egypt, and various countries conquered by Mahomet, helped to shape Moorish or Saracenic art. This art is entirely confined to architecture and ornament—which is generally applied to architecture—since painting and sculpture, or the creation of images, were strictly forbidden by the law of Mahomet. Even in architecture the Mohammedans did not arrive at a settled style, and their buildings show a curious mingling of sober bareness on the exterior and exuberant ornamental fancy in the decoration of the interior. The mosques do not follow a fixed plan, prescribed by the use to which they were put, like the Christian churches, but are arranged in a haphazard fashion, the only common members being a spacious court with a fountain for ablutions, a hall for prayer, the "Holy of Holies" for the keeping of the Koran, and slender minarets for the muezzin's call to prayer. Columns and arches are abundantly used for the extensive halls and arcades, and the inner walls are covered with a wealth of arabesques and ornamental motifs in coloured tiles and carved stone.

Domes are extensively used, and the arch received a variety of new forms in the hands of the Arabs, who introduced the pointed arch, composed of two segments of a circle meeting in the centre of the arch; the horseshoe arch, formed of a segment of a circle which considerably overlaps the semicircle, and the ogee arch, which rises from each side like a semicircle and then turns upwards until the two lines meet in a point.

Examples of Saracenic art abound in Turkey, in India, in Western Asia and North Africa, and in Spain. The Alhambra in Granada, the famous palace of the Moorish Kings, and the Taj-Mahal at Agra, the tomb of world-wide renown, are among the most famous buildings of this type.

P. G. KONODY

Characteristics and Use of Blood. Its Composition.
Blood-Vessels and Their Work. The Heart and its Action.

CIRCULATION OF THE BLOOD

JUST as beneath our streets are three sets of pipes conveying gas, water, and sewage, so throughout the body are three sets of vessels coloured, by the fluid within them, red, white, and blue. The red vessels convey arterial blood from the heart; the blue return venous blood to the heart; and the lymphatics convey the drainage of the body cells into the venous blood near the heart, together with the digested fat from the food. These three sets of pipes are very numerous, and present many complications, which we will consider presently. Our first business is to examine the blood which flows through the vessels, then to consider the vessels, and, lastly, to describe the heart that pumps the blood throughout the body.

The Blood—the Life of the Body. All the life of the body depends upon the quality and regular circulation of the blood. Our thoughts, our powers, our actions, depend upon its regular supply in proper quantity and quality to every part and every organ of the body. The brain is particularly sensible to any failure in the blood supply, and arrangements are made there that nothing may interfere with its circulation.

The Blood. The blood is a *heavy, red, opaque, warm, alkaline, saltish* fluid, with sometimes a faint odour characteristic of the animal to which it belongs. It is emphatically a living fluid, not only in the sense that upon it, as we have said, depends the existence of the body, but because it is full of life. It is the sole means, as we have seen, by which the varied and complex products of digestion, on the one hand, and oxygen, on the other, are conveyed to all the tissues and to every body cell, there to be reduced to forms of a less complex nature, the force liberated in the process being partly used in the passive life of the cells, and partly in the various active phenomena. The blood is, therefore, with the aid of the lymph, the carrier between the digestive and respiratory organs on the one hand, and the living body cells on the other, the blood-vessels forming, at the same time, a complete warming apparatus for the body. Blood is *heavy* as compared with water, the one having a specific gravity of 1000, the other of 1056.

28. SECTION OF VEIN AND ARTERY
V. Vein. A. Artery. 1. Advent[illegible] fibrous coat. 2. Mi[illegible] muscular coat. 3. Intima, or lining membrane. 4. Nuclei of cells of

Colour and Heat of Blood. The *colour* of blood varies from bright scarlet to dark purple. In the *arteries*, and also whenever exposed to the air, it is bright red. Hence, it is bright red in the superficial capillaries just beneath the surface of the cheek. In the *veins* it varies from dark purple to red, getting brighter in proportion to the activity of the part or organ whence it comes. The blood is opaque, owing to its being a mixture of solids and liquid.

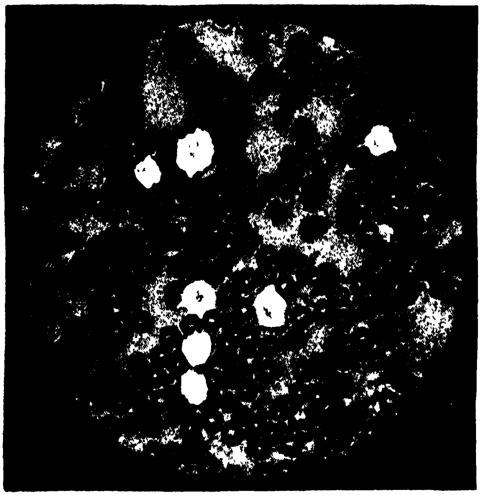
The average *blood* heat near the surface of the body is 98·4° F., and is about the same in health in all temperatures, "warm-blooded" animals, as we have seen, having constant blood-heat, independent of their surroundings, in contradistinction to "cold-blooded" animals, whose blood is not necessarily "cold," but varies with the surrounding medium.

The temperature of the blood in the deeper vessels is said to range between 100° and 107°. Its temperature is also increased in passing through large glands, notably the liver. The blood is *alkaline* in life, but out of the body it soon becomes neutral, and then acid. It is saltish from the presence of common salt. The *quantity* of the blood may be taken as about one-thirteenth of the weight of the body; a quarter of it is contained in the heart, lungs, and larger vessels; a quarter in the liver and its vessels, a quarter in the muscles, and a quarter in the circulatory vessels [32].

The Cells in the Blood. To the naked eye blood is simply a red fluid; but when we examine it microscopically we find that it is swarming with millions and millions of solid particles which have been called "blood cells" or "blood corpuscles." These cells are of two kinds, distinguishable by colour, size, and shape, and known as *red cells* or *corpuscles*, and *white cells* or *corpuscles*.

The red corpuscles, so-called, are not really red; viewed individually by transmitted light they are seen to be yellowish in colour, but in bulk they appear red, and it is owing to them that blood has its characteristic red colour. In shape, they are like round discs or biscuits, and their surfaces are slightly concave, so that they are thinner centrally than marginally. In size, they are microscopic, measuring only $\frac{1}{3200}$ of an inch in diameter. In number, their name is legion, for there are five million in every cubic millimetre of blood, and it has been calculated that if spread out flat they would cover an area of about thirty square miles. Structurally, the red cell is composed of a framework of protoplasm containing in its meshwork a transparent viscid red substance known as *hæmoglobin*, and it is probable that there is a fine cell wall, but there is no nucleus. It is to be observed that the characteristic constituent of the red

corpuscles is the hæmoglobin, for hæmoglobin has a remarkable affinity for oxygen, and gives the red corpuscles their capacity for carrying that gas. As the blood passes through the capillaries of the lungs, the hæmoglobin in the red cells takes oxygen from the air in the air cells, and becomes converted into *oxyhæmoglobin*, and as the blood circulates through the tissues, the tissues take the oxygen from the oxyhæmoglobin



29. WHITE CORPUSCLES AND RED CORPUSCLES OF THE BLOOD

and convert it into hæmoglobin again. The red corpuscles live for about two weeks, and during that time they make about 20,000 journeys to the lungs to collect oxygen, and the same number of journeys to the tissues to supply them with the oxygen they have collected.

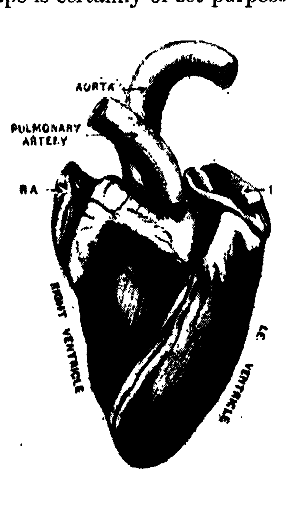
The red corpuscles seem to be formed chiefly in the marrow of the bones and in the spleen, and after severe loss of blood they are said to be produced at the rate of 175 million per minute. In anæmia and other diseases, however, they diminish rapidly in numbers.

White Corpuscles. The colourless or *white corpuscles* [29], discovered by Hensen (1773), are larger than the red ($\frac{1}{3500}$in. diameter), but are only spherical in death; during life their shape constantly varies. Like the red corpuscles, they have no cell walls, but, unlike them, they have one or more distinct nuclei. They have a finely granulated appearance, which, on examination under a higher power, is seen to be due to a meshwork that pervades them, the corners of the meshes being formed into knobs; part of the granules may be food material. The colourless corpuscles, or leucocytes, of the blood are identical with the smaller description of lymph cells that are found all over the body, and particularly in the spleen and lymphatic glands. The function of these cells has long been doubtful, and is only now beginning to be understood. They have very active habits during life. Possessing the power of traversing the walls of the blood-vessels with the greatest ease into the lymph space around, or into the body tissues, they are found in enormous numbers wherever any active inflammation is going on, and when dead they form the principal part of pus or "matter."

Enemies of Bacteria. Professor Metchnikoff, of the Pasteur Institute, regards white corpuscles as our defenders against microbes of all sorts, and has lately shown how active they are in eating and destroying bacteria and germs, and also refuse of all kinds; while the curious fact has been discovered that from Peyer's patches in the intestine, where they abound, they migrate into the tube, seize on all the bacteria they can find, and carry them down into the deeper tissues, where they and their spoil both become the prey of a larger description of lymph corpuscle, called giant cells.

Enough has been said to show what a life of varied interest and usefulness white corpuscles lead, and to encourage us to hope for still further discoveries respecting them. They increase rapidly by fission, which the red corpuscles never do, and appear in amazing quantities in a very short time wherever they are wanted. The spleen is one great source of their origin, and in the splenic vein they number 1 to 80 of the red corpuscles.

The most remarkable feature about these corpuscles is their constant change of shape (which is always very irregular) by *amœboid* movements, so-called from their similarity to those of the *amœbæ* of stagnant waters. The great distinction between these and the red corpuscles is that the power of the former is distinctly vital; their change of shape is certainly of set purpose, as when they enclose a particle of food; they probably exercise, too, some distinct influence over the plasma, whereas the red corpuscles are merely oxygen carriers.



30. THE HEART
Showing the front external view with the aorta

The Plasma. Having considered the cells in the blood, let us now look at its fluid part, or "plasma." The *plasma*, or liquid part of the blood, is nine-tenths water, is of a yellowish colour, and contains carbonic acid gas, albumen, fats, glycogen (liver sugar), and salts in addition.

It has, because of other bodies contained in it, a most remarkable power of *clotting* or coagulating—a process, indeed, on which our life depends. As will be seen in the section on HEALTH, there is a class of people in whom this clotting power is either wholly absent or so feeble as to be useless, and these people are in imminent danger of bleeding to death, even if a

tooth is extracted. Huxley gives the following simple experiment to demonstrate this power of clotting.

"Twist a piece of string pretty tightly round the middle of the last joint of the middle or ring finger of the left hand. The end of the finger will immediately swell a little, and become darker coloured, in consequence of the obstruction to the return of the blood in the veins caused by the ligature. When in this condition, if it be slightly pricked with a sharp, clean needle, a good-sized drop of blood will at once exude. Let it be deposited on a slip of thick glass, and covered lightly and gently with a piece of thin glass, so as to spread it out evenly in a thin layer. Let a second slide receive another drop, and to keep it from drying let it be put under an inverted wine-glass, with a bit of wet blotting-paper inside. Let a third drop be dealt with in the same way, a few granules of common salt being first added to the drop.

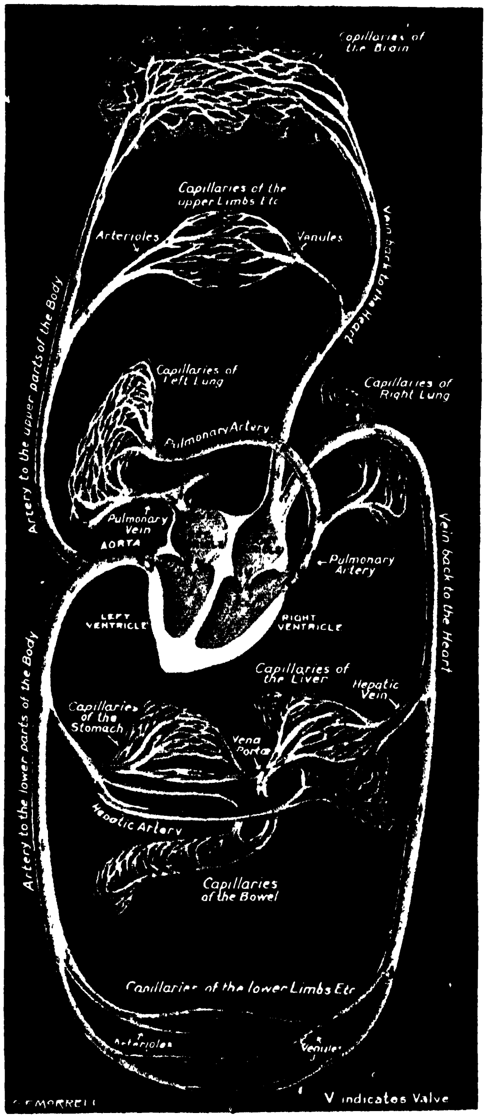
31. VEINS, SHOWING THE POCKET-LIKE VALVES

"To the naked eye the layer of blood upon the *first slide* will appear of a pale reddish colour, and quite clear and homogeneous; but, on examining it with a pocket lens, its apparent homogeneity will disappear, and it will look like a mixture of excessively fine, yellowish-red particles like sand or dust, with a watery, almost colourless, fluid; and immediately after the blood is drawn the particles will appear to be scattered very evenly through the fluid, but by degrees they aggregate into minute patches, and the layer of blood becomes more or less spotty." The particles are the red corpuscles of the blood; the nearly colourless fluid in which they are suspended is the plasma.

The *second slide*, prepared as described above, may now be examined. The drop of blood will be unaltered in form, and perhaps may seem to have undergone no change. But if the slide be inclined, it will be found that the drop no longer flows, and, indeed, the slide may be inverted without the disturbance of the drop, which has become solidified, and may be removed, with the point of a penknife, as a gelatinous mass. The mass is quite soft and moist, so that this setting or *coagulation* of a drop of blood is something quite different from its drying.

On the *third slide* this process of coagulation will be found not to have taken place, the blood remaining a fluid, as it was when it left the body. The salt, therefore, has prevented the coagulation of the blood. Thus this very simple investigation teaches that blood is composed of a nearly colourless plasma in which many coloured corpuscles are suspended, and that this coagulation may be prevented by artificial means, such as the addition of salt. The coagulation is brought about by the changing of a part of the plasma into a branching mass of fibrous tissue called *fibrin*, in the meshes of which myriads of the red corpuscles are entangled.

Why the Blood Clots. As the clot is thus formed, a thin, straw-coloured fluid is squeezed out, called the *serum*, which is practically plasma deprived of its fibrin. The value of this clotting power is, of course, in its solidifying the blood at



32. THE CIRCULATORY SYSTEM

the mouth of a cut artery or vein, so that it can no longer flow, thus stopping up the open end of the vessel. Blood never clots in a healthy vessel during life, but sometimes the blood may clot in diseased veins, and thus become a great source of danger by blocking the circulation. Clotting in the blood is hastened by any solid bodies in the blood, by heat at 100° F., by retardation of the circulation, by small doses of

calcium chloride, by the action of air, by deficiency of water, and by injury or disease of vessels. It is deferred by increase of water, cold or great heat, by an alkaline solution (salt), and by being in living blood-vessels. Arterial blood clots more quickly than venous blood.

On the whole, blood has a similar chemical composition to that of muscle.

The Blood-Vessels. We now turn to the blood-vessels, which include two out of the three sets of pipes in the body; the third, or the lymphatic, we speak of in the next chapter.

33. THE POSITION OF THE PULSE (X)

The *arteries* [28] are so called because by the ancients they were always supposed to contain air, as after death they were always found empty. They are stout tubes that remain round even when empty, and are made of three coats, the outer (the *adventitia*) being fibrous for protection, the middle (the *muscular*) to regulate the size of the vessel, and the inner one (the *intima*), a delicate membrane of living cells which have many active functions to perform, not least of which is to aid in removing impurities, germs and the like, from the blood. So that we must distinctly understand that there is nothing dead or mechanical about either the blood or blood-vessels. The former is filled with active living white corpuscles; the latter lined with many active living cells, which have a definite duty.

The Aorta. The arteries begin in one strong vessel, the *aorta* [30], 1 in. in diameter, which, as it leaves the heart, soon subdivides into six branches– two for the head, two for the arms, and two for the legs. These divide and subdivide as they run along the protected inner sides of the limbs and all over the body, like the branches of a tree, till the tiniest twigs are so small that they can hardly be seen by the naked eye, and these are called *arterioles*.

Arteries are elastic and, always being a little overfull, they are ever on the stretch, and so maintain that gentle pressure on the blood that keeps up the flow between the beats of the heart. When an artery ruptures, the inner coat folds over inward as it contracts, and thus at once begins to stop the flow of blood.

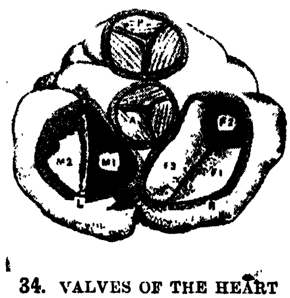
A short distance from the end of the *arterioles* the smallest *veinlets* begin, and rapidly uniting form large trunks which lie alongside of the arteries, until at last the united volume of blood is returned to the heart by two great veins, each the size of the aorta, called the *superior* and *inferior vena cava*.

Veins. *Veins*, like arteries, have three coats, but, unlike them, these coats are so thin that an empty vein flattens and collapses. They also differ from arteries, especially in the limbs, in having a remarkable arrangement of valves [31], the value of which will be apparent when we come to speak of the circulation. These valves are in pairs, an inch or so apart, and are made to open toward the heart, so as to afford no obstruction to the progress of the blood in that direction, but to close at once if it tries to turn back. The walls being thin, they more easily bulge under pressure than those of arteries.

Capillaries. Until 1661 this was all that was known of the blood-vessels, and it was believed that the blood was poured out into the tissues by the arteries, to be picked up a short distance off by the veins. It was then discovered, however, that between the two an intricate network of tiny microscopic blood-vessels (called *capillaries*) exists, some $\frac{1}{3000}$ of an inch in diameter extending all over the body in such inconceivable numbers that it is almost impossible to insert the point of a pin anywhere without piercing one of them. The whole body thus consists of tiny islets of cells surrounded by capillaries, which themselves lie in lymph channels. These tiny vessels have but one coat, but as we have fully described them and their remarkable functions in the last chapter, we need not recapitulate here. They extend to thousands of miles. If the arteries begin in one tube 1 in. in diameter, and the veins end in two tubes with a united calibre of 1½ in., the united calibre of the capillaries is represented by a tube of about 2 ft. in diameter [31].

The Heart. We must now proceed to describe the mechanism by which the circulation of the blood is maintained by the elaborate pump called the heart.

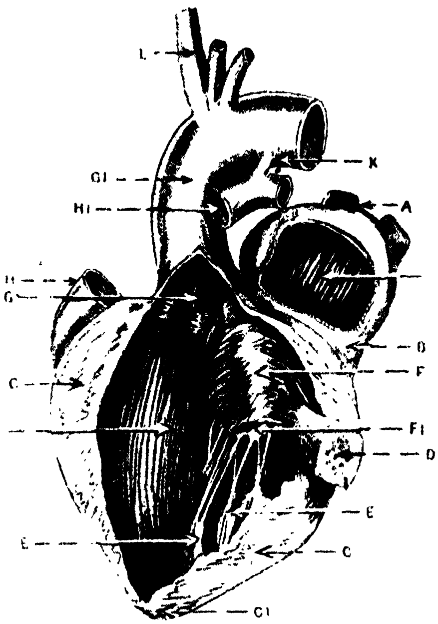
The *heart*, enveloped in the double layer of the *pericardium*, is in the form of a blunt, hollow cone about the size of its owner's fist. It weighs about 9 oz., and is situated behind and somewhat to the left side of the lower half of the *sternum*, or breast-bone. Its base is uppermost and to the right, its apex being downward and toward the left. It consists, like the arteries and veins, of three coats; an outer fibrous coat, called the *pericardium*, which really consists of two layers, forming a closed sac, the heart being folded up in it. The inner layer is closely adherent to the heart, and the outer layer to the connective tissue around, a small amount of fluid being between the two.



34. VALVES OF THE HEART
A transverse section. *A*. Aorta. *P*. Pulmonary artery. *M* 1 & 2, Two flaps of mitral valve. *F* 1, 2, & 3. Flaps of tricuspid valve. *L*. Left side. *R* Right side

An illustration may help us to understand how the pericardium is arranged. Take two thin paper bags, of which one is slightly smaller than the other, so that one may be contained within the other, both being fully distended. Now slightly fold back the edge of the mouth of the

inner bag, and gum it all round to the edge of the mouth of the outer one. There is now a double bag made with an inner and an outer layer, and a small space between them, completely shut off from the outside. Suppose the closed fist to be just large enough to fill the inner bag, it will represent the heart, to which the inner layer of the pericardium is adherent. The wrist will represent the great vessels passing



35. HEART WITH LEFT CHAMBERS EXPOSED

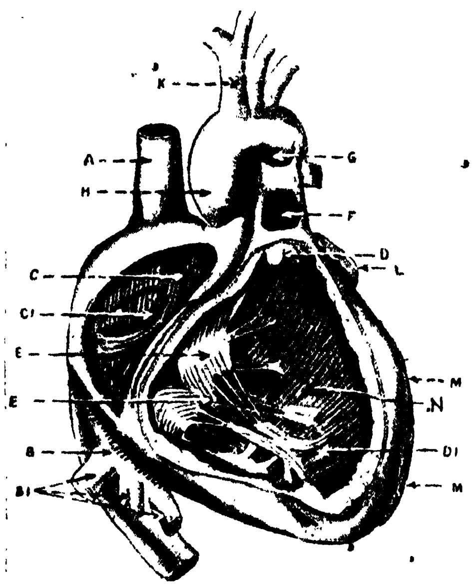
A. Pulmonary veins. *A* 1. Left auricle. *B* Wall of auricle. *C*. Wall of ventricle. *C* 1. Apex of heart. *D* Fleshy column attached to valve. *E* Musculi papillares and cordae tendineae attached to valve. *E* 1. Left ventricle. *F*. Mitral valve. *F* 1. Opening of valve. *G* Semilunar valves of aorta. *G* 1. Aorta. *H* Pulmonary artery. *H* 1. Pulmonary artery. *K*. Attachment by ductus arteriosus to aorta. *L*. Arteries to head and arm

off from the heart, around which the neck of the double bag extends. All the serous membranes which enclose the various organs—brain, lungs, digestive organs—are made on the same principle.

Muscles of the Heart. The *middle*, or muscular, coat forms the main substance of the heart itself, and in a muscular man varies from a quarter of an inch to an inch in thickness; while the *inner* coat is the lining membrane of the heart. The muscle is peculiar, for the fibres are intermediate between the striped, or voluntary, muscles of the limbs and the unstriped, or involuntary, muscles of the arteries. They have transverse stripes and contract altogether like the former, but are not under the control of the will, thus resembling the latter. They are arranged in circular, oblique, longitudinal, and (toward the apex) in spiral layers. They continue for some distance along the two large veins. The fibres that surround the upper half of the heart are distinct, and can contract separately from those around the lower half. The muscular coat around the heart varies immensely in thickness. It is thinnest around the upper half of the heart on both sides, the auricles, because the work here is slight, and only consists in forcing the blood, as the auricles contract, into the two lower cavities, ventricles. It is twice as thick on the lower right side, for this has to do twice as much work in pumping the blood through the lungs; and it is more than twice as thick again in the left lower half, because this ventricle has to pump the blood all over the body. The thickness of the muscle everywhere is in proportion to the amount of work it has to do.

Chambers of the Heart. Inside, the heart in man is divided longitudinally into two halves, right and left; each half is again divided transversely, thus making four chambers in all. In fish there are but two, in a frog three, while in the crocodile upward we get four. All these stages are passed through in the human embryo [35].

The two upper chambers are called respectively the right and left auricles, because on the top of each is a small flap like a dog's ear, and the Latin word *auricula* means a little ear. They have very thin muscular walls. The two lower ones are called the right and left ventricles (Latin, *ventricula*, a little belly), and have much thicker



36. HEART WITH RIGHT CHAMBERS EXPOSED

A. Superior vena cava. *B*. Inferior vena cava. *B* 1. Hepatic veins. *C*. Right auricle. *C* 1. Opening for veins. *D*. Valves of pulmonary artery. *D* 1. Fleshy columns. *E* Tricuspid valve. *E* 1. Cordae tendineae attached to valve. *F*. Pulmonary artery. *G* Attachment to aorta. *H* Ao[illegible] *K*. Vessels from aorta. *L* Appendix of left auricle. *M*. Left ventricle. *N* Right ventricle

walls, the left being also at least three times the strength of the right. Each chamber holds about four tablespoonfuls of blood. There is no direct communication between the right and the left side of the heart after fœtal life.

Trap-doors of the Heart. Each auricle communicates with the ventricle below by a sort of large trap-door in the floor, which on the right side consists of three flaps, and is

called the *tricuspid valve*, and on the left of two, and is called the *mitral* or *bicuspid valve*. The right auricle has, in addition to this valve, the large opening (*sinus venosus*) common to the terminal veins [36].

In the right ventricle is the opening of the *pulmonary artery* which conveys the blood to the lungs to be purified, guarded by a *semilunar valve* which has three flaps. The centre of each margin has a little node (the *corpus arantii*), the three meeting when the valve closes. The bulging of the wall of the artery behind the valve is called the *sinus of Valsalva*. The parts in the aortic semilunar valves are similarly named. The left auricle has four openings for the four *pulmonary veins* that return the purified blood from the lung to the heart; and in the left ventricle is the large opening of the *aorta*, by which the blood finally leaves the heart, guarded by a *semilunar valve*, which has three flaps as in the right ventricle.

There are thus in the heart [35] three valves with three flaps (two semilunar and one tricuspid), and one with two flaps (the mitral). The arrangement of all these valves is such that the blood can only pass in one direction, always from the venæ cavæ toward the aorta. The orifices of the valve are strengthened by thick, fibrous rings, while the flaps of the tricuspid and mitral valves are stiffened and prevented from rising too far by strong bands (*musculi papillares*) and cords (*cordæ tendineæ*) fixed from the inner surface of the ventricle to their lower side. Fleshy pillars (*columnæ carneæ*), from which these cords spring, are also seen on the inner surface of the heart.

The two arteries (pulmonary and aorta) come from the front of the heart, while the six veins, two venæ cavæ and the four pulmonary veins, enter at the back. There are thus eight large blood-vessels connected with the heart, three with the right side and five with the left. On the right the two venæ cavæ returning blood from the body to the right auricle, and the pulmonary artery (the only one in the body conveying venous blood) carrying the blood from the right ventricle to the lungs. Then on the left the four pulmonary veins from the lungs enter the left auricle, and the aorta leaves from the left ventricle.

Action of the Heart. The heart contracts by nervous mechanism in the organ itself, and is thus regulated by the brain. The heart muscle alone has a remarkable inherent contractile power, which is dependent on no external nervous energy nor even on the nerve centres in the heart, nor on blood in the heart. Contraction has been seen in bits of freed heart muscle, and appears to be absolutely *automatic*. No other muscle has this power, and there is no other muscle even in appearance like the heart muscle.

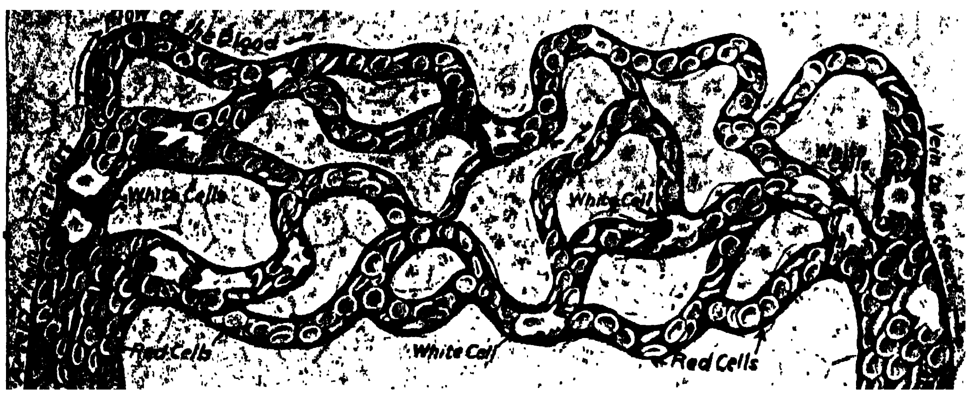
The heart as a whole, cut out from the body but supplied with blood, will beat for days. If supplied with oxygen instead of blood, for twelve hours; if with air, for three; if in a vacuum, for half an hour; if with CO_2, in each case it stops. There are in the heart three or more nervous centres from which undoubtedly energy is supplied; and bits of muscle containing them beat more vigorously than those without.

Then, besides this, the frequency of the contraction is regulated by two nerves. The one, the *pneumogastric*, slows the beat, and pressure on it may stop the heart altogether; the other, the *sympathetic*, accelerates it, and the influence of the emotions, causing the heart to beat more quickly under excitement, explains how that organ came to be regarded as the seat of the affections, with which it has really nothing to do.

The heart has no nerves of sensation, and hence it can feel nothing, and such a thing as pain *in* the heart is impossible. Even in angina, the only painful heart disease, the spasm is believed to be in the arteries, and especially in those arteries (the coronary) that supply the walls of the heart itself with blood.

The heart on rare occasions is transposed and may be found beating on the right side of the body instead of the left. In disease it is frequently greatly enlarged.

A. T. SCHOFIELD



37. THE BLOOD PASSING THROUGH THE CAPILLARIES

The capillaries are really very minute, some 2000 to the square inch. In this drawing the capillaries and the red and white cells of the blood have been greatly magnified for the purpose of showing clearly what happens in the circulation of the blood.

Ploughing, Harrowing, and Sowing for Wheat, Barley, Oats, and Root Crops. Drilling Seeds. Weeds and Their Prevention.

CULTIVATION OF FARM CROPS

It is the custom among farmers to grow the various crops on the arable land upon a system of rotation. It will be well to explain not only what that system is, but the principles upon which it is based. It is a commonly accepted maxim that it is bad farming to grow two white straw crops—by which we mean cereals—in succession on the same land. Highly skilled farmers, however, are able to grow these crops from year to year continuously with most excellent results by maintaining the cleanliness and fertility of the soil.

The rotation system, however, is to be preferred. It enables the farmer to raise a greater variety of crops, to maintain stock, such as cattle and sheep, and thus to produce abundance of farmyard manure, which is practically impossible where the land is employed, however skilfully, for growing grain crops alone. The rotation system not only preserves but promotes fertility. If a cereal crop is taken from year to year, it becomes necessary to provide manures containing nitrogen with great liberality, but although phosphatic manure is essential for some time, mineral fertilisers collect in the soil to a greater extent than they can be utilised for want of some other crop which would draw on them.

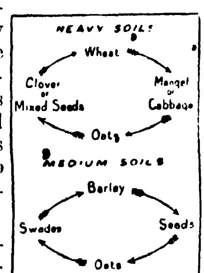
Dominant Fertilisers. Nitrogen is the dominant fertiliser of the cereals, phosphoric acid of turnips, and both phosphoric acid and potash of the pulses, clover, and other leguminous crops. If, therefore, we alternate these crops upon a recognised system, we enable one to feed upon the residue of fertility left in the soil by another, and in its turn to provide something for the crop which succeeds it. When a grain crop succeeds clover or beans, it is enabled to draw upon the store of nitrogen which these plants have extracted from the atmosphere and left in their roots. When the soil has been exhausted of available phosphoric acid and potash, it is once more supplied with these materials through the medium of such fallow crops as the turnip or the potato, both of which it is usual to manure, under good farming, with dung as well as artificial fertilisers.

In a rotation a grain crop usually succeeds both the mangel and the potato, and is thus provided with what it requires, although in many cases it may still be advisable, where farming on the intensive principle is followed, to give dressings of both phosphatic and nitrogenous manures. This is the more necessary for the reason that, under the four-course system of rotation, clover, or a mixture of one or more varieties of clover and rye grass, or of mixed grasses, is sown in spring with the growing cereal, to become in its turn a crop for feeding or mowing in the following year. The demand for food is therefore considerable, hence the importance of adequate preparation.

Value of Rotations. There are, however, other reasons why a system of rotation is advisable. By no other method is it possible to maintain the land in a clean condition—in a word, to destroy weeds. This cleaning is effected where plants, such as the mangel, the swede, the potato, the cabbage, kohl-rabi, or beans, are grown in rows wide enough apart for the horse-hoe to be employed between them and the hand-hoe in the rows of plants themselves. Crops like the turnip or the cabbage, being frequently eaten off by sheep, indirectly improve the lighter soils, for the manure which is dropped adds fertility, while the compactness which follows the herding of the flock ensures a more perfect seed-bed. Again, the rotation system enables the farmer to keep within limits the ravages of insect and fungoid parasites. The crop being changed, the enemy, whose attacks are confined to a particular variety, practically finds its occupation gone; whereas, if a crop which has been seriously attacked—as the turnip with the fly or with the fungoid disease known as anbury—were grown again upon the same field within one or two years, the probability is that the damage would be more serious.

The diagram suggests two methods of four-course rotation. In that suitable to the heavier classes of soil, mangel or cabbage may follow wheat, and be succeeded by oats, or even by barley, where this plant can be grown with success. This corn crop may be followed by clover, or a mixture of clover and grasses, the seeds having been sown with the oat or barley crop, to be followed again by wheat, for which they have prepared the way.

Where it is inconvenient to take wheat—which is an autumn-sown crop, although under bad conditions sowing is sometimes delayed until nearly Christmas—oats may be taken, and where the necessary ploughing becomes impossible owing to bad weather wheat sowing is abandoned, and an oat crop is usually taken after ploughing the land later on.



Systems of Ploughing. The system of ploughing adopted by a farmer depends chiefly upon the soil, but largely upon custom. Deep ploughing should never be resorted to if it brings the subsoil to the surface. It is important, however, to plough as deeply as

possible without harm in this direction for all fallow crops. Deep ploughing, too, makes the soil more porous, and paves the way for shallow ploughing in the case of most succeeding crops, which are thus more quickly started in life.

The dung produced upon the farm is usually employed for the wheat, mangel, and potato crops, but on many occasions land is also dunged for swedes, cabbage, kohl-rabi, and maize. The fertility of dung is not all utilised by the crop for which it is provided, a portion remaining for the benefit of succeeding crops.

Rotation for Lighter Soils. In the rotation designed for the lighter soils, seeds are sown with the barley crop, which succeeds swedes which have been eaten off by sheep. The feeding of sheep on the land enriches the top three or four inches of soil, through which the roots of barley ramify in search of food. Assuming that the swedes have been grown by the aid of superphosphate, and that the sheep have also received cake, corn, and hay, it follows that the manure which they drop, both liquid and solid, not only contains a large proportion of the phosphates which were distributed on the soil for the benefit of the swedes, and which they have consequenctly taken up, but the fertilising constituents of the artificial food.

It is not surprising, therefore, that even poor, thin soils, such as those resting on gravel and chalk, are enabled to produce heavy crops of grain and straw, and to retain a sufficient residue of fertility for the benefit of the clover or mixed seeds which are cut in the succeeding year. In many large sheep-breeding districts these seeds, which may embrace sainfoin, sown alone, are, like the swedes, consumed by sheep receiving cake and corn, and thus the land is once more doubly enriched for the benefit of a succeeding oat crop, which many advanced farmers would assist with a dressing of such an artificial manure as sulphate of ammonia. This manure, on light soils, is preferred to nitrate of soda, as it is much less soluble, and, consequently, not so likely to be lost in the drainage water.

Four-Course Rotation the Best. There are other rotations employed by farmers in various parts of Great Britain, but the four-course or Norfolk, rotation, to which we have specially referred, is the best foundation which can be laid. The greater, however, the grasp of principles, the better able is the farmer to form a rotation for himself, should he desire to make any change. Such a man will be able to take "catch" crops, to which we shall presently refer, and to replace one crop by another, or to allow his clover mixture or seeds to remain a second or even a third year before ploughing up for a succeeding grain crop.

Ploughing Land for Wheat. Wheat is usually sown on land which has been dunged and which belongs to the heavier class of soil. The land is ploughed early, harrowed, and the seed drilled. In some of the lighter land districts where wheat is grown the soil is ploughed rather shallow, furrows are made with a ring-presser to provide a firm bed, and the seed is broadcasted and covered with the harrows. Heavy land often needs weathering after ploughing before harrowing is possible, by which we mean that the sticky, clay-like soil turned over by the plough must be brought to such a condition by the aid of wind, rain, sun, or frost that it will break to pieces when the harrows are drawn over it. As wheat needs a firm bed, care must be taken not to plough too deeply, nor to make the soil too loose. Wheat being an autumn-sown plant, it is often essential to make water-furrows to prevent rain collecting and thus destroying it.

Barley's Place in the Rotation. The object of the barley grower is not only to obtain a large yield, but fine samples for malting purposes. In spite of foreign competition and the employment of barley-malt substitutes, a good sample will still realise a respectable price; but a sample which is unfit for malting falls to a low figure, owing to the much smaller value of this cereal for feeding purposes. Quality depends upon the soil, the season—especially during ripening and harvesting—and the method of cultivation. In the most suitable districts the barley crop is a profitable one, but in unsuitable districts, and largely on heavy soils, it is much more difficult to obtain quality. Barley is very commonly taken after a root crop fed off by sheep, for the reason that it thrives upon the enriched shallow surface soil, upon which the flock has been folded to eat off swedes, turnips, sainfoin, rape, kale, and other plants provided for them. It is, however, a recognised principle that a field intended for barley should never be too rich, or a sample may be spoiled. When, therefore, its condition is higher than is desirable, oats or wheat may be taken before the barley. Barley is also taken after a potato crop, this tuber, being a gross feeder, seldom leaving too large a residue of plant food, unless it has been heavily manured.

Sowing Barley Seed. It is most essential that barley should be sown in a very fine seed-bed, and this is another reason why it should follow a root crop, for, in preparing for roots by several cultivations, the tilth is made both deep and mellow. In such a case the land needs but a shallow ploughing, the object being to provide fineness above and firmness below, and yet the soil must be dry. The seed-bed must be prepared in dry weather by using the most appropriate implements, as the curved tined or drag harrow, the medium spiked harrow, and the roller. Above all, poaching (*i.e.*, trampling by the horses) must be avoided, especially where the soil runs together and becomes impossible of cultivation when trodden upon. In order to obtain evenness of growth, the seed should be drilled, that it may be deposited at an equal depth. Covering may be completed with light harrows, that the soil above the seed may remain in a mellow condition.

Spring and Winter Oats. Oats are sown in two seasons, although the winter oat, which is drilled in early autumn, is common to but few districts. The grain of the winter

variety is preferred by many owners of horses, especially of hunters, while the straw is much superior in strength and form to that of the spring oat, which is usually sown between the end of January and early April. When the weather is open, the earlier the sowing the better. The seed-bed may be deeper than for barley, but it is not necessary to produce so fine a tilth, the oat being a vigorous growing plant, and thriving on almost all classes of soil which are sufficiently provided with food, and which are clean and dry. The system of broadcasting the seed is quite common, but more seed is required, while the plants appear with much less regularity, so much so that at harvest it is not uncommon to find the majority well ripened while the minority are still almost green.

Peas. Formerly it was the more general practice to sow the earliest peas in autumn, but in these days farmers prefer early spring. The pea demands a tolerably fine seed-bed, for which reason the land should be ploughed as soon as possible after the previous crop has been removed. The first drilling may be in January, if the weather permits, the blue-flowered varieties being selected, further sowing following from time to time until the middle of March. As the season advances, the later varieties are sown. Land intended for peas should not be touched during wet weather, for, where poaching follows the treading of horses and men, success is impossible. Care must be taken to guard against the depredation of birds, especially of the wood-pigeon.

Beans. Beans are commonly taken after wheat on strong land, and are sown early in the year, what are known as winter beans being first selected, the spring varieties following in due course. The bean stands moderately severe weather without harm on dry or well-drained land. It requires a fairly deep seed-bed, which need not be exceptionally fine in tilth. The land should be ploughed in autumn, that its condition may become sufficiently mellow, and, a suitable day being selected, it may be harrowed down and drilled at once. When drilling is impossible, the method of dibbling may be resorted to, for it occasionally happens that sowing would otherwise be much delayed owing to the impossibility of taking the horses on to the land without damage. In dibbling holes are made with a hand-tool, and the seed deposited in rows at equal distances apart. Before the bean plant appears, harrows may be drawn over the field with the object of killing weeds which may have begun to grow; when the rows are sufficiently defined, the horse-hoe may be employed with the same object. Land intended for beans is occasionally manured with dung, covered in by the plough in autumn.

Roots. By the preparation of the soil for the root crops, by which we mean mangels, kohl-rabi, swedes, and turnips, although potatoes may be appropriately included, the whole rotation is affected. If the work is good, it tells upon the general yield of the four-course rotation; if, on the other hand, it is imperfect or bad, the farmer may be prepared for some disappointment at the result.

It may here be remarked that there are two classes of fallow, the one applied to land which carries fallow crops, among which roots are included; the other known as bare fallow, chiefly applied to very heavy land. The object of bare fallowing was formerly intended to provide the soil with a rest, and to give it time to accumulate fertility before it was asked to produce another crop. In these days, bare fallowing is chiefly resorted to for the purpose of cleaning land, ploughing being conducted from time to time during the hot weather of summer, when, by the aid of the sun, weed-life is destroyed. The more this subject is studied by the student the more clearly it will be shown, however, that, unless in exceptional cases, a bare fallow is a waste. If it is regarded as impossible to grow a saleable crop with profit, it is preferable to sow for a green crop, which may be ploughed in as green manure, and thus to prepare a field for a profitable succession.

Elements of Successful Root Crops. A successful root crop largely depends upon early autumn ploughing. The land intended to carry mangels should first be tackled—if possible, immediately after harvest. If time permits, it may be skimmed 2 to 3 in. deep with the broad share, which not only accomplishes quick work, but destroys growing weeds, and induces weed seed to sprout ready for subsequent burying with the plough. In this work the sun may possibly be an available helper. Subsequent work with the harrows will largely remove such obnoxious weeds as twitch or couch-grass before the plough starts its work. In some cases, especially on light soils, the steam cultivator is introduced, and the land is twice stirred, one cultivation crossing the other. Such practice makes it easier for the horses when ploughing.

On the heavier soils, which have been similarly prepared and harrowed, the soil being dry, the land may be ploughed to a depth of 6 to 7 in. If this is permissible, as it should be for the mangel, which flourishes best on deep, strong, rich loams, the soil may be subsequently ploughed with the ridging plough, and left rough through the winter. By this means the clods will be pulverised by frost, the soil forming the ridges will remain fairly dry, while the rain-water will find its way into the furrows between.

Autumn Ploughing. So much depending upon autumn cultivation for roots, the necessity of early sowing and harvesting will be recognised. But it must not be supposed that early autumn ploughing is essential for roots alone. The land may be prepared for wheat and beans, oats and barley, where it is intended that the seed for these crops should be sown early. Land should not be touched with plough, harrow, or roller while it is wet, although there are some of the lighter soils upon which work may proceed very quickly after heavy rain, and here experience is important. Roots not only demand a fine and deep tilth, for which reason a fine surface tilth should not be buried, but they demand sufficient

moisture near the surface to encourage the early germination of the seed. How important this point is will be seen if the thick, hard husk in which the seed of the mangel lies is examined.

Drilling of Mangels and Turnips. Both mangels and turnips are drilled upon the ridge on the heavier soils; the whole of the soil forming the ridge should, therefore, be fine. Before ridging for the drill with the double-breasted plough—this being the final operation with this implement—root land is usually spring ploughed once or twice, according to its condition. When this is sufficiently perfect, the ridges are drawn, usually 27 in. apart, and the furrows between manured with rotten dung, and where mineral fertilisers are employed, with these also. The plough then passes through the middle of each ridge, splitting it in halves, covering the manure, and at the same time forming the ridges. These are subsequently pressed with a light roller—for it is essential to prevent the soil "running" or sticking together by extreme pressure—and on the flat surface thus produced the seed is drilled. Swedes and turnips germinate better when drilled quickly after this operation, and while the land is still moist. Swedes are sown between the middle of May and the beginning of July, depending upon the district and climate, the dates of sowing being earlier in the South than in the North. Turnips are sown during June and the first half of July, while stubble turnips, frequently broadcasted, are sown between the middle of July and the last week in August.

The student will do well to notice the difference in the rapidity of the germination of turnip seed on a coarse or dry tilth and on a fine, moist, fresh tilth, which has been lightly rolled. The mangel, owing to its preference for stronger soil, is generally sown on the ridge, with manure beneath; while the swede, although the same system of manuring is sometimes followed, is more commonly manured with phosphatic manures alone.

It is important that in all cases the ridges upon which roots are grown should not be less than 27 in. apart in order that the horse-hoe may be more easily and advantageously employed in keeping spaces between each row of plants perfectly clean. The mangel plants, which, with successful germination, produce almost unbroken rows, are subsequently singled with the hand-hoe, each bulb being left from 9 to 15 in. from its neighbours. The wider the bulbs are apart the larger they grow, but while medium bulbs involve more labour in lifting at harvest, they are richer as a food. Mangels are frequently grown on the flat on the lighter soils, for the reason that they better obtain the necessary supply of moisture.

Mangels and Weeds. Owing, however, to the fact that weeds grow more quickly than the mangel plant, it is a good practice to mix with the mangel seed in the drill a small quantity of turnip seed, which appears earlier than the mangel plant; then the rows may be seen sufficiently early to introduce the horse-hoe before the weeds have taken absolute possession of the soil. The mangel is sown between the end of March and the middle of May, and the variety selected will depend upon the experience of the grower. Some find the Globe or Tankard superior to the Long Red, which is more difficult to lift owing to the fact that a large proportion of the roots grow within the soil. For this reason it frequently breaks off in pulling, involving extra labour or loss. The object of the grower, however, should be not only to obtain weight per acre, but weight of food per acre, and this he will secure by selecting varieties which are known to contain a high proportion of feeding matter, and to grow them closer together in the rows than usual.

Where blanks occur in a mangel field they may be filled up by planting cabbage or kohl-rabi, unless, swede seed having been sown with the mangel seed, plants of this root are in possession. Whether the mangel land has been supplied with dung, after ploughing in autumn, or under the seed in spring, it may be advantageously dressed with nitrate of soda during its early growth. This fertiliser may be supplied at the rate of ½ to ¾ cwt. per acre when the young plants have been a fortnight above ground, while a second and similar dressing may be provided when they are half grown.

Clovers and Seeds. Clover is usually sown alone, a common practice with the broad red and crimson varieties, to which reference has been made; but under varied conditions, depending upon the purpose for which the crop is required, and upon some soils, the character of which must always be consulted, mixtures are sometimes preferred. These mixtures may consist of the clovers proper—broad red, cow-grass, alsike, and white, or one or more of these varieties added to Italian rye grass, or, where the plant is to remain on the ground for two years or more, yet temporarily, with the addition of cocksfoot, cat's-tail, and occasionally lucerne and smooth and rough stalked meadow-grass, as shown in the chapter on grasses. Temporary mixtures are usually known as "seeds," or "leys," and the seeds are sown with a corn crop.

Clover is usually drilled, especially where it is grown with wheat, but the seed should not be deposited more than half an inch in depth. Where, as should be the case, the soil covers the seed after the drill, it may be found sufficient to roll it, otherwise, as where it is broadcasted with the seed-barrow, it should be covered with light harrows, and subsequently rolled. In some instances it is sufficient to cover with a bush-harrow, skilfully made by fixing a number of strong blackthorn boughs to a hurdle or an implement equally convenient. Again, some farmers find it satisfactory to cover the seed with a horse-rake, but in all cases rolling, the weight of the roller depending upon the class and condition of the soil, should follow. The farmer, too, must judge whether he should sow his mixture of seeds at one or two operations. The seed-barrow is of great width, and takes a long sweep, but, careful as the workman may be, he frequently misses the line of seeding, with the result that when the plant appears many places

are recognised which were never seeded at all. This is prevented by dividing the seed into two portions, and sowing the second portion across the first. In using the seed-barrow it may constantly happen, too, unless care is exercised, that the small, heavy clover seeds remain at the bottom of the box, and are not equally scattered with the grass seeds by the brushes within.

Time for Drilling Seeds. Occasionally seed is drilled with spring corn, but on soils where the tilth is fine and deep this is liable to bury the fine clover and grass seeds, which prefer a shallow, firm bed. The more general practice is to wait until the oats or barley have appeared, and are sufficiently strong to permit of the drill being used, or for the operation as conducted with the seed-barrow. Both sainfoin and lucerne, which may be regarded as seeds, are similarly drilled with or among growing corn, but in no case is the crop obtained in the same year, although, where the growth is precocious, there may be sufficient green food cut when the corn is harvested to improve the value of the straw. The cropping of clover, sainfoin, and lucerne assists in renewing the fertility of the soil, but it is inadvisable to allow either plant to remain down long enough to become so foul that the land is in part impoverished by weeds, or rendered difficult to clean and cultivate for a succeeding crop.

In some cases, where the soil is foul, beans may replace clover in the rotation, for the reason that the land, as already explained, can be horse-hoed between the rows forming the crop. Land intended for seeds should always be well supplied with lime, which may sometimes save a plant from the ravages of the eel-worm, the chief enemy of broad clover. With this object half a ton of ground lime, preferably produced from chalk, may be sown per acre.

Forage or Catch Crops. A "catch" crop is a crop which is taken between two regular or rotation crops, as crimson clover sown upon wheat stubble, and removed sufficiently early in spring for turnips to be sown. These crops include crimson clover, vetches or tares, rye, winter barley, and oats, all of which should be sown early in the autumn, that they may be cut green and removed early in spring. Before sowing it is advisable that the land should be well cleaned by surface-harrowing for the destruction of growing weeds, and to incite the germination of weed seeds. The land, except for trifolium (crimson clover), which is sown upon the harrowed stubble, should be shallow ploughed, and the seed drilled and harrowed in while the surface is dry and kind. Where, however, time permits, deep ploughing is advisable, inasmuch as it will materially help a succeeding root crop. Catch crops are always assisted by the provision of a dressing of artificial manure where the soil is not in the best of condition. But for trifolium and vetches phosphatic manures are recommended, and for the cereals a combination, not a mixture, of phosphatic and nitrogenous manure (sulphate of ammonia).

Eradication of Weeds. It is an old proverb that "a weed is a plant out of place"; thus the wheat plant is a weed in a barley field, and vice versa. Where weeds are practically suppressed, a farm is regarded as clean; where, on the contrary, they grow with freedom, the land is termed foul. One of the most costly processes in agriculture is the cleaning of a foul farm, for the land is actually in possession of perennial and other weeds of the worst character, which are most difficult to suppress. Large numbers of the most prominent weeds are annuals, and therefore easily destroyed by ordinary means; but the worst of weeds, which are chiefly perennial, are only eradicated by hand labour or deep ploughing. These, which are the farmer's worst enemies, include couch or twitch, dock, thistle, nettle, buttercup, daisy, coltsfoot, ragwort, knapweed, and bindweed; while among the worst of annuals are charlock, poppy, wild radish, mayweed, and dodder. The worst weeds, however, are not all found upon the same soils; they have their preferences,

AUTUMN PLOUGHING ON A FARM IN ESSEX

some growing naturally upon the clays, others upon the chalks, and others again upon the sands. Thus they may indicate the class of soil which lies beneath the surface.

How Weeds are Introduced. Weeds may be introduced to the land through the seed which finds its way from the stable or the cattle-house into the manure. Hay and straw commonly employed for stock as commonly contain a more or less important proportion of dried weed plants, which shed their seed. Grass seeds, too, present in the hay, are frequently conveyed in the manure to the arable land; hence one reason in favour of allowing manure to heat before it is ploughed under the soil, for in the process of decomposition the seeds are destroyed. Where a corn-stack has been threshed, weed seeds are deposited in large quantities, and one of the commonest sights on the average farm is the growth of docks and thistles around the stack-yard, or in the corner of the field in which a stack has stood. Many weeds are conveyed from the plant to the field by the wind; others adhere to the feet of birds, and are deposited elsewhere. Again, a field may be easily inoculated with weeds by the employment of impure seed, especially that which is too often used by careless farmers—we refer to the sweepings of the hay-loft. The roadsides, the hedgerows, unclean land on an adjoining holding, all contribute to the labour of suppressing weeds on a farm which is well managed, and nothing is more essential in clean farming than the extension of the labour of weed suppression to every hedgerow and to the sides of the road which adjoin the farm.

Why Weeds Need Suppression. If weeds are numerous they obtain the mastery, and while the crop is thinned, the soil becomes foul, entailing great cost in cleaning and feeding. Weeds rob the cultivated plant of the food which it needs, of the moisture which enables it to appropriate food, and of the light, which is so essential to healthy growth. There are weeds, like ramsons (wild garlic) and meadow saffron, which communicate their flavour to milk and butter, and which must at any cost be suppressed on land occupied by a dairy herd. Where weeds are numerous and their growth rank, they clog the reaper in the process of cutting and tying the corn, and not only are they the cause of frequent damage or even breakage of machinery, but they delay the work.

If weeds are allowed to have their way for a short time, they make the cultivation of land for an immediate crop practically impossible. A foul field may necessitate the omission of a year's cropping altogether, and this loss is increased by the necessity for several ploughings, with the object of exposing the roots of the weeds to the destructive heat of the sun. Where land is kept clean there is no necessity for summer fallowing of this character. Weeds harbour many of the pests of the farm, fungi as well as insects. Farm pests of the worst type are seldom dangerous on land which is kept clean and in good heart.

How to Suppress Weeds. One of the most prominent and destructive of weeds is the yellow-flowered charlock, or kedlock, or wild mustard, which many farmers have in the past attempted to destroy by "heading"—*i.e*, cutting off the head or flower with the scythe or hook. This practice is most destructive and costly, and should never be adopted. The charlock may be removed by hand-pulling, or, still better, destroyed by spraying with a solution of sulphate of copper to which quicklime has been added. Preparations for spraying a variety of crops are now in the market.

Although it is possible by frequent ploughing at sufficient depth to destroy docks, thistles, and nettles, and similar deep-rooted, tenacious plants, by far the best plan is to extirpate them by hand. Annual weeds are easily destroyed by harrowing during dry weather, and in large part checked by the introduction of a flock of sheep, especially on the stubble after the removal of the corn, with the object of their consuming the weeds before the majority have shed their seed. It has been remarked that the poppy, the most gaudy as well as one of the worst of weeds, may produce over 10,000 seeds on a single plant; hence the enormous importance of preventing the seeding of this species.

Weeds and Cultivated Lands. Weeds which love wet soil quickly disappear when it has been drained, while by the process of high cultivation—by which we mean the liberal supply of manure—most of the weeds in pastures and meadows vanish, owing to what we may term the better fighting power of the cultivated grasses and clovers, which, in response to an increased supply of food, develop more vigorous powers of growth.

JAMES LONG

THE MOST OBNOXIOUS WEEDS OF THE FARM

A = Annual. B = Biennial. P = Perennial.

ARABLE	MEADOW AND PASTURE
Corn Cockle, A.	Rest Harrow, P.
Chickweed, A.	Buttercup, P.
Charlock, A.	Daisy, P.
Wild Radish, A.	Hogweed, B.
Willow-herb, P.	Knapweed, P.
Coltsfoot, P.	Cowslip, P.
Mayweed, A.	Dandelion, P.
Oxeye Daisy, P.	Self-Heal, P.
Bindweed, P.	Plantain, P.
Knot Grass, P.	Sorrel, P.
Nettle, P.	Dock, P.
Dock, P.	Ladies' Smock, P.
Goosefoot, A.	Ladies' Bed Straw, P.
Horsetail, P.	Ragwort, P.
Poppy, A.	Spear Thistle, B.
Spurrey, A.	Marsh Thistle, B.
Shepherd's Purse, A.	Meadow Thistle, P.
Groundsel, A.	Yellow Rattle, A.
Sow Thistle, P.	Mallow, P.
Dodder (clover fields), A.	Meadow Saffron, P.
Broomrape (clover fields), P.	Ramsons, P.
	Sedge (wet pasture), P.
	Rush (do.), P.
	Moss (do.), P.

Elements in Series and Species. What is a Metal?
The Elements with their Atomic Weights and Symbols.

THE AFFINITY OF ELEMENTS

THE meaning of the periodic law can only be that the elements are not really elementary, "specially created," as we used to think that living species had been, but are versions, or compounds, or derivatives of some "one element," which is simply undifferentiated matter, and yields all the kinds of elements we know, and many besides, by the various forms which it is capable of assuming.

Compounds as Series. Chemistry furnishes us with a notable series of facts which will help us. When we study the "chemistry of the carbon compounds," we find that there are many long and regular series of compounds which show various characteristics in a regular way. For instance, the first member of the series may be a gas, the next few may be liquid, and the "higher" members of the series may be solid at ordinary temperatures. Numerous other features will show the same regular variation as we ascend from the "lower" to the "higher" members of such a series for instance, the well-known series of the alcohols. Chemical analysis has shown that, in such series, each member differs *structurally* from the last in a regular way. For instance, every successive member of the series called alcohols is a compound containing, in each smallest possible portion of itself, one atom of carbon and two atoms of hydrogen more than the last.

The Elements as Series. Similar ideas can be applied to the elements. If we take a series or group of elements, such as we have seen to exist, and to occur at regular intervals according to the periodic law, may we not imagine that the atoms of successive members of such a series have got some feature of their structure repeated each time, just as one atom of carbon and two of hydrogen are repeated in each successive member of the series of compounds called alcohols?

Along such lines of thought progress is now being made. Just as each new member of the alcohol series is made by the addition of similar atoms to those which form the member just before it, so we can imagine that the atoms of successive elements in a series are formed by having some kind of material repeated in their structure, so that we get something different, and yet similar. If we think of an atom of some element as like an inside box of a child's familiar toy, then the atom of the next element of its series might be like that box *plus* the next largest box, of the same shape and material, placed outside it, and so on. This may seem a very childish sort of comparison, but it closely suggests the very theories upon which experimenters are now working.

Where Chemistry Joins Physics. At this point chemistry, in the familiar sense of the word, comes to a standstill. Its customary methods, so fruitful hitherto and in other respects, are inapplicable here We can put elements together and cause them to combine, we can examine their behaviour in hosts of ways, but ordinary chemical experiments will tell us nothing as to the *structure* of the atoms of the elements with which we deal. Indeed, what may be called orthodox chemistry, or the chemistry which was orthodox until the last decade, practically denied the existence of any such questions as those of the architecture and composition of atoms. Yet we must go forward, and at this point we learn that chemistry must use the methods of physics, and, above all, of the department of physics which deals with electricity. The ultimate problems of chemistry, dealing with the nature of atoms, are problems of matter in general, which is the business of physics.

The Elements as Species. In 1905, in his Presidential Address to the British Association, the late Sir George Darwin, a son of Charles Darwin, put forward what is now known to be a profound and valid comparison. Remembering the theory of organic evolution, as laid down by his father, Sir George Darwin suggested that we might look upon the elements as species, and the atoms of the elements as the individuals of any species, and even that such species of elements could come into being, exist, and disappear, as in the case of living species. Today we can surely say that he was right, and further, that, as all living species are related, and all are variants of life—whatever that may be—so all the elements are related, and all are variants of the elementary form of matter—whatever *that* may be. Only by the faithful study of details can the naturalist hope ever to solve all the problems of life, and only so also can the chemist solve the problems of matter; but it would be hardly fair to leave the subject, as we now must, without very briefly noting here what the modern physicist-chemist, for he is both, is beginning to show.

A Fourth State of Matter. The evidence accumulates in favour of the theory that there is a "fourth state of matter," in which it is neither gas, liquid, nor solid. In this state the various atoms of the various elements are reduced to *their* elements, which seem to be similar in all cases. The presumption raised by the periodic law is justified by these electrical researches which show that all the atoms of all elements are compounded of one and the same kind of unit, or *real* atom, which is a particle having marked electrical properties and commonly known nowadays as an "electron." Having noted so much, our business is now to take up in detail that study of the various elements and compounds which constitutes

chemistry in the older sense of the word, and which is of greater practical, though perhaps less philosophical, importance today than ever before.

Oxygen Free and Combined. The elements we can enumerate, and which exist long enough—it may be for millions of years—for us to study them at any length, are sometimes met with in their uncombined or free state, while sometimes we can only study them by first disengaging them from their compounds. Many elements are to be found in both conditions—they occur to some extent in the free state, and are also met as constituents of compounds. The oxygen of the atmosphere is an instance. There it exists free in vast abundance, and also, to a relatively small extent, combined with hydrogen to form the water-vapour of the atmosphere, and with carbon to form the carbonic acid gas or carbon dioxide, which is also a constant ingredient of the atmospheric mixture.

Free nitrogen, we have already seen, is abundant in the atmosphere. When we pick up the stones or clay or sand beneath our feet, as samples of the earth's crust, we find that these things, as a rule, are compounds, though if the stones happen to be diamonds they will be exceptions, for diamonds are elementary carbon. The elements found in the compounds which make most of the rocks and the earth's crust in general are oxygen again, silicon and aluminium. And if we consider the oceans, again we find abundance of oxygen as one of the two elements which are combined in the formation of water.

Elements "Left Over." If we look at all the elements which are to be found making up land, sea and sky, oxygen is found to constitute about half of the whole, though it is not much more than one-fifth of the atmosphere. Already we know enough of chemistry to be able to interpret this fact. The oceans mostly consist of oxygen combined with hydrogen; the land mostly consists of oxygen combined, above all, with silicon, and with many other elements also, headed by aluminium. But for rare and comparatively trifling exceptions, all these elements are combined with oxygen, and the free oxygen which remains in the atmosphere may almost be looked upon as the surplus, which was left over when all the various elements, beginning with hydrogen, were combined with oxygen long ago to form the compounds which now constitute very nearly the whole of land and sea.

The Elements Under Heat. The study of the chemistry of the sun, which must later engage us, will serve to explain the tremendous chapter of chemical history of which the results are before us, and under our feet, and round our bodies. At very high temperatures, the compounds of oxygen with other elements, and, indeed, compounds in general, cannot exist; the heat, so to say, drives apart or keeps apart atoms which would otherwise combine. The sun illustrates that state of things now, for we can prove the presence of our familiar terrestrial elements there, but *as elements*, uncombined. The earth, we have clear evidence, was once intensely hot, as the sun is (though not necessarily at the same temperature as the sun now is), and in those conditions the compounds which we now know could not exist.

But gradually, we must believe, the temperature fell, and the time would come when most of the atoms of the other elements which can combine with oxygen—hydrogen, and all the rest—would do so, producing water and all the other compounds which we are about to study. This was a process of combustion or burning, and must itself have produced a great deal of heat, thus retarding, to some extent, the age-long process of earth-cooling. And our present atmosphere, we observe, almost wholly consists of nitrogen, which has very little tendency to unite with oxygen, and of oxygen itself, which has, so to say, been left over from the vast quantity of free oxygen which once formed part of the atmosphere of the earth, and so much of which was later combined with other elements to form our land and sea.

The Metal Group. If we had samples of all the known elements before us, and were asked to group them, one of the groups, and much the largest, would certainly consist of what are called the metals. These are of immense importance for civilisation, as the very names of past epochs of human history serve to show; and, indeed, their practical manipulation and working constitute one of the most important of all branches of human industry today. The science of METALLURGY needs a course to itself, but here we may briefly note a few of the characteristics which lead the chemist to pick out certain elements from all others, and call them by the common name of metals. They have a "metallic" glitter or lustre, they are usually heavy elements, they conduct heat well, and electricity well—a most important fact—and they are also variously capable of being melted, drawn into wires, beaten into plates, or otherwise made to assume various shapes, as most other elements are not. In this way they often discharge invaluable services for mankind. We have seen that they are usually heavy; and, with the single and strange exception of mercury, all solid at ordinary temperatures.

Man Before Metals. The list of the recognised and stable elements still falls far short of a hundred, but more than fifty of them are metals. Six of them—gold, silver, tin, copper, iron, and lead—were familiar in their elementary or metallic form to the ancient world—though, as has been already noted in this course, time was when man had no knowledge or control of any metal in its metallic state, and in that Age of Stone little progress or none was to be expected—so important are the physical properties of the metallic elements. Not that man was, even then, without the use of iron, for it was, as it is, an essential constituent of every drop of his blood.

False Tests of Metals. The student will now rightly demand a definition of the metals, but this is not so easy as might be supposed. It used to be thought that, in order to call an element a metal, it must be capable of being melted by heat, without undergoing any other change, and of being beaten out into plates by a hammer. An element which has these characters is said to be respectively fusible and malleable. The

malleability of gold is remarkable, even among the elements, as the thinness of the finest gold leaf testifies. The notion that mercury was a metal seemed impossible at one time, because solidity was regarded as essential for the metallic state. But mercury can be frozen, and then there is no doubt that it is an element. In fact, the question of solidity or non-solidity is clearly of no chemical importance, for anything may be solid, liquid, or gaseous, according to temperature. The other metals are merely frozen — or, as we usually say, solid—at higher temperatures than mercury; or, to put it in another way, if we began with all the metals hot and liquid, and cooled them, mercury would be the last to freeze; that is all.

Weight also is not a satisfactory test of a metal, for the metal lithium is the lightest solid known. Again, there are elements which behave like metals and look like metals, but are brittle instead of being malleable; so that breaks down as an absolute test of a metal. In fact, it is better to abandon all such tests, though not forgetting how widely they do apply, and instead we may note a purely *chemical* test, part of which we have already learnt incidentally.

Bases, Acids, and Salts. In general, a metal is capable of combining with oxygen, and such a compound will be called an oxide of the metal in question. Much of the "dry land" consists of such oxides, or is derived from them, and we have already seen how they must have been formed, *after* the period when metals and oxygen all existed *free* in the atmosphere of the earth, as they do now in that of the sun.

But chemistry has a special name for the oxide of a metal. These compounds are called *bases*. Now, non-metals also combine with oxygen (a word which means *acid-maker*), and such compounds are called *acids*. When acids and bases act upon one another *salts* are formed. Here, then, are three fundamental terms which must be learnt and understood, for they occur incessantly in all chemical discussions. For the moment, these facts specially interest us as showing that there is a real meaning in the grouping of certain elements as metals, even though most or all of the general notions of a metal break down in this instance of a metal or that. They have a common chemical behaviour, common "chemical affinities," as used to be said, and on those sufficient and profound though mysterious grounds, far more significant than "metallic glitter" or malleability, we may retain and recognise the great division of the elements into metals and non-metals.

Elemental Groupings. What we have just learnt is typical of the kind of thing that chemistry has to study—the elements, their simple compounds, and the fashion into which these fall into groups, any member of one of which tends to react in a definite chemical way with any member of another. Hence "laws" can be formulated and predictions made, which will be true, under similar conditions, everywhere—in a fireplace, or a retort, or the human brain, or the leaf of a plant, or the atmosphere of a planet, or the interior of the furthest star. There are not several kinds of chemistry, but one chemistry, of which living and not-living matter, the earth, the sun and the stars, are all illustrations. This is the simple and colossal statement which gives the chemist his significance.

The Work of the Chemist. When the chemist combines a metal with oxygen to form a base, and when he combines a non-metal with oxygen (and water) to form an acid, and then puts together a few drops of each in a little tube of glass, to form a salt, he is repeating, on a tiny scale, the very processes by which the world as we know it has been evolved; and thus, in short, every reaction which he observes, on however small a scale, may contribute to our knowledge of the history and the destiny of man, or of the Milky Way. Oxygen is oxygen everywhere and at all times, and behaves accordingly. Nature is uniform, consistent; we hold a kind of epitome of the heavens in a grain of sand; and the student working in his laboratory is as surely "thinking the thoughts of God after him" as the astronomer, the psychologist, or any lofty philosopher whatever. This is to be remembered when we work away at small and tiresome details; each of them is an essential part of the Universal Whole.

So far as we yet know, the matter of the Universe is composed of the elements given in the list on page 842. But this list of the elements is not to be looked at without the remembrance of two facts; first, that these are not ultimately elements, and second, that they include merely the elements of long duration. The "short-lived" elements, intermediate evolutionary forms, between certain of those in this list, are of unknown number, and may be far more numerous than all the elements here named. Opposite the name of each "permanent" element, as chemists are beginning to call them—though the term is only relative, for none are eternal—is placed a letter or two which is known throughout the civilised world as the "symbol" of the element. It is simply a convenient, brief name, agreed upon internationally, and invaluable for the study of chemistry.

The Origin and Importance of Symbols. Usually the symbol is derived from the Latin name of the element, and is easily remembered. The student *must* familiarise himself with the symbols of the more important elements, or he can get no further. He will find that this becomes quite easy, for soon the symbols seem as "natural" as the names themselves. In the third column is a figure which is what is called the "atomic weight" of the element, a phrase which we shall very shortly consider in exact terms. A table like this is never anything more than provisional. The time has passed when we may expect that any of the names in it will disappear, through a discovery that the supposed element is a mixture of other elements already in the list. The symbols may also be counted upon as fixed. But the student must not regard the list as complete, for additions will doubtless need to be made to it in the future, even though we can scarcely expect anything so surprising as the discovery of several

elements in the atmosphere, as happened with and after the discovery of argon. As for the "atomic weights," they vary to some extent according to different authorities. There has been a serious difficulty about the atomic weight of radium, for instance, and many chemists occupy all their time in the "re-determination of atomic weights," in order to obtain more exact results than those now available.

Further, in this table, we give round numbers, *as if* all the other elements had atomic weights which were exact multiples of the atomic weight of hydrogen, which is put down as one. That would be very significant if it were so, but really it is not so, and the relations between the atomic weights of the various elements are by no means so simple as this table, or any table confined to round numbers, must suggest.

The Study of Atomic Weight. The laborious task of calculating the atomic weight of an element is immensely worth doing today, because we *know* that the elements are related; that atoms of one kind of element are discharged from, and formerly formed sub-atoms of, the atoms of another element; and therefore the exactest possible estimation of the relative weights of these atoms is essential for our solution of the greatest of chemical problems—the nature and construction of atoms themselves. But also these calculations are invaluable because they may lead to the discovery of new elements. One chemist had been using one method, and another another. They get different results, and the difference remains when the work is done over again. Then inquiry shows that there is an unknown factor at work in the one case, but not in the other, and that unknown factor may be a new element. It was in this fashion that argon was discovered, an element which constitutes about one per cent. of the atmosphere, but of which no one had guessed the existence previously.

Oxygen as a Standard of Weight. When first the attempt was made to form a table of atomic weights, the meaning of such a table was thought to be much simpler than we can now believe. The lightest atom is that of hydrogen. Take it as the unit, and call it one. Other atoms are found to be, often very closely, mere multiples of that unit; oxygen comes out at about sixteen, carbon at twelve, and so on.

Hence we may guess that the oxygen atom is really sixteen hydrogen atoms in some kind of close combination, and so with the atoms of other elements. The relative weights did not always come out as round numbers, yet they were very nearly so, and perhaps experimental error might account for the difference. But it does not do so. For instance, taking the atomic weight of hydrogen as one, a host of observations, by various methods, over many years, show beyond doubt that the atomic weight of oxygen is *not quite* sixteen. The simple theory must be abandoned, for this fact disposes of it. Indeed, chemists have found that there is a more convenient method than the older one of taking the lightest atom as the unit and calculating the others from it. A better plan is to call the atomic weight of oxygen sixteen (instead of nearly sixteen), and to calculate all the other atomic weights relatively to that. For some remarkable reason, which must be significant, we find that an astonishing number of other atomic weights now come out as whole numbers, or very nearly whole numbers, and even though we now have to call the atomic weight of our lightest atom 1·008 instead of 1, the new table is simpler and therefore much easier to remember than the old one was. C. W. SALEEBY

Name	Symbol	Atomic Weight	Name	Symbol	Atomic Weight	Name	Symbol	Atomic Weight
Aluminium	Al	27	Hydrogen	H	1	Ruthenium	Ru	102
Antimony (Stibium)	Sb	120	Indium	In	114	Samarium	Sm	150
Argon	A	40	Iodine	I	127	Scandium	Sc	43
Arsenic	As	75	Iridium	Ir	193	Selenium	Se	77
Barium	Ba	137	Iron (Ferrum)	F	56	Silicon	Si	28
Beryllium	Be	9	Krypton	Kr	81	Silver (Argentum)	Ag	108
Bismuth	Bi	208	Lanthanum	La	138	Sodium (Natrium)	Na	23
Boron	B	11	Lead (Plumbum)	Pb	206	Strontium	Sr	87
Bromine	Br	80	Lithium	Li	7	Sulphur	S	32
Cadmium	Cd	112	Magnesium	Mg	24	Tantalum	Ta	183
Caesium	Cs	133	Manganese	Mn	55	Tellurium	Te	124
Calcium	Ca	40	Mercury (Hydrargyrum)	Hg	200	Terbium	Tb	160
Carbon	C	12	Molybdenum	Mo	97	Thallium	Tl	204
Cerium	Ce	140	Neon	Ne	20	Thorium	Th	232
Chlorine	Cl	35	Nickel	Ni	59	Thulium	Tm	171
Chromium	Cr	52	Nitrogen	N	14	Tin (Stannum)	Sn	118
Cobalt	Co	59	Osmium	Os	195	Titanium	Ti	48
Columbium	Cb	94	Oxygen	O	16	Tungsten (Wolfram)	W	184
Copper	Cu	63	Palladium	Pd	105	Uranium	U	240
Didymium	Di	142	Phosphorus	P	31	Vanadium	V	51
Erbium	Er	166	Platinum	Pt	195	Xenon	Xe	128
Fluorine	F	19	Potassium (Kalium)	K	39	Ytterbium	Yb	173
Gadolinium	Gd	156	Praseodymium	Pr	140	Yttrium	Yt	90
Gallium	Ga	70	Radium	Rd	225	Zinc	Zn	65
Germanium	Ge	72	Rhodium	Rh	103	Zirconium	Zr	91
Gold (Aurum)	Au	198	Rubidium	Rb	85			
Helium	He	2						

The Struggles by which Rome Attained Supremacy Among the Peoples and Towns of Italy, and The Punic Wars.

THE RISE OF THE ROMAN STATE

Early in the eighth century, about the time when the Phœnicians were founding their great advance post at Carthage, on the northern coast of Africa, and when the Homeric poems were being composed in Hellas, the story of Rome was beginning. The traditional date of the founding of the city was the year 753 B.C. Whether that date is accurate or not, somewhere about that period Italy between the Apennines and the Western sea was in the occupation of two races. North of the River Tiber, the Etruscans, a non-Aryan race, had established themselves. They may have been akin to the pre-Hellenic inhabitants of the Ægean Islands, but this is merely a matter of conjecture. South of the Tiber the Latins, who were of Aryan stock and were distinctly akin to the Hellenes, had taken possession of the great plains and the foot-hills. Down upon them from the north and east were pressing the more nearly related tribes of the Sabellians, Sabines, or Samnites, names which are all probably variants of one original title. The Latins were establishing themselves in cities in the same fashion as the Greeks.

The site of Rome is a strong strategical position, commanding the passage of the Tiber. According to the tradition, Romulus, the son of the war god Mars and one of the "vestals," built the city and established himself there with a band of warlike followers over whom he ruled; and he was succeeded by six other kings, the last of whom, Tarquin the Proud, was expelled in 509 B.C., at the very time when the Athenians were ejecting their own tyrants.

Probably Latins founded the city as a frontier fort, and there were long struggles, during which Sabines and Etruscans occasionally dominated it. Certainly we need not believe in the actual seven kings, who were supposed to have reigned for 244 years, with an average of 35 years apiece! Evidently, however, the dynasty which was finally expelled was Etruscan, and their expulsion was a victory of the combined Latin and Sabine elements in the city. We must remember always that the city meant not merely the actual walled town, but, in addition, the extensive agricultural districts attached to it.

Rome became a state ruled by the families of high descent who were called "Patricians;" to all Romans from thenceforth the name of king was as detestable as was the name of tyrant to an Athenian. At the end of some two hundred years Rome had achieved an ascendency over all Italy west of the Apennines. At the end of another century she had resisted and shattered the attack of Carthage, and was mistress of all the Mediterranean lands west of the Greek peninsula. In another seventy years her dominion was beginning to expand into Asia itself.

There are three aspects under which the story of Rome must be reviewed—the struggle with rival states; the struggle between the Patrician, or noble class, and the ordinary freemen, or Plebeians; and the methods by which Rome succeeded in uniting Italy under her leadership.

At the beginning of the fifth century, when the Greeks were on the point of engaging in the great struggle between East and West, it was doubtful whether non-Aryan Etruscans or Aryan Latins and Sabellians were destined to dominate Italy. The moment of the struggle between Persia and Western Hellas was seized by the Oriental Carthaginians to engage in a struggle with the Eastern Hellenes in Sicily. The Etruscans would seem to have seized the same opportunity to develop their attack upon the Aryans.

Though the Romans expelled the Etruscan dynasty, it is doubtful whether the Latins, of whom they were the leaders, would have proved successful in the struggle but for the fact that the Sicilian Greeks successfully repelled the Carthaginian attack at Himera, in the same month as Salamis, and immediately afterwards utterly shattered the Etruscan fleet. This great blow to the Etruscans was probably decisive in enabling the Latins to hold the Etruscans behind the lines of the Tiber. The struggles of Rome thenceforth are not with a united power of Etruria, but with great Etruscan cities.

with the invading Sabellian tribes, and with Latin cities which disputed the supremacy she was achieving by the ceaseless wars—forced upon her by her strategic position. About the end of the fifth century, when the Peloponnesian war came to an end, Rome finally destroyed her most powerful Etruscan rival, Veii.

The Celtic Tide. For some time past the Celtic tide had been flowing through the Alpine passes into the plain of the Po. Then the deluge burst over the Apennines, broke up the Etruscan power, and surged up to the walls of Rome herself. Rome was captured by the Gauls. Then the invading tide ebbed again; a Roman army inflicted a decisive defeat upon the Gauls by the River Allia, and the Celts disappeared again over the Apennines.

Grievously though Rome must have been shaken by the Gallic onslaught, her triumph at the Allia proved that she had not been crushed. Mainly upon her had rested the defence of Latium, the states of the Latin League, against the incursions of the Sabellian mountaineers. She did not lose the supremacy which she had won. But the Latin League like the Delian League was growing restive; Rome was becoming more and more mistress, instead of merely a leader. Many of the Latin cities revolted; the result only strengthened the Roman position, and the Latin League was broken up, the cities becoming nominally allies, but actually subordinates of the city on the Tiber, though with varying degrees of independence.

Rome Predominant. Then came the final struggle with the Sabellians, who had been penned back on the north-east, but who now, under the name of Samnites, were pressing upon the south-east of Latium and Campania. The Samnite wars did not end with the subjugation of the Samnites, but in a treaty which left them in complete independence, as allies with Rome on equal terms.

Now, in the early days of the Latin League the various cities of the League were theoretically on an equality. But united action could not be imposed upon them. For the mere purposes of mutual defence it became imperative for Rome, in the exposed position which she held, to claim the right of controlling alliances and of deciding when the League should go to war and when it should make peace. Equality disappeared. In the course of time there resulted an arrangement under which cities were admitted to the League only upon conditions which constantly strengthened the position of Rome in relation to her allies. Rome claimed for her own citizens freedom of trade in the other cities, and, in effect, the position of full citizens. But she did not permit to her allies free access to her own markets or the right of marrying into Roman families.

During the fourth century she developed the concession of grades of privilege. There were cities which entirely lost their individuality as states by simple enrolment among the citizens of Rome—a privilege actually less than it sounds, because it was only dwellers near Rome who could take part in any of the Roman political assemblies. The representative principle had not yet been discovered, and personal attendance was necessary. On the next plane were the cities to which were granted all the ordinary civil rights of Roman citizens, but without any political franchise. These came to be known as the cities with "Latin rights." On a still lower plane were the cities which after the dissolution of the Latin League itself were allowed to enjoy local self-government, but had neither the political franchise nor the civil rights of Roman citizens. The control of war and peace and the conduct of the armies remained entirely in the hands of Rome, as in effect did the whole military organisation. This method guaranteed the protection of Rome or of the power of Rome to all her allies, while all had before them the prospect of the concession of further privileges if they rendered loyal service to the common cause. It was only at a still later stage that a yet lower grade was created of towns, or (in the mountains) of tribes, directly subordinate to a Roman magistrate.

Rule by Magistrates. The monarchy had been replaced by magistrates, at the head of whom were the two consuls, the chief magistrates at home, and commanders-in-chief of the army in the field. They could not make laws; actual legislation was the function of the assemblies, the *Comitia*; but it was only by the magistrates that a new law could be submitted. The double magistracy was a security against one man converting his office into a "Tyranny."

The magistrates were elected by popular vote, but only Patricians were eligible. They could, on an emergency, nominate a "dictator," endowed with supreme and sole authority for a term of six months. They were expected to be guided by the council called the Senate; but the Senate itself was a Patrician body.

Magistrates exclusively Patrician naturally viewed most questions from the point of view of their own order. A few years after the expulsion of the Tarquins, the Plebeians formed an organisation to protest against the existing system. The Roman legions had just returned to Rome, after a conquering campaign, when they received a command to prepare for a second expedition. The legionary soldiers were all Plebeians, and at this serious crisis resolved to act together for their common interests. Reforms had for some time been promised them, and they now demanded that these reforms should be made realities.

The Effects of Patrician Narrowness. The Patricians would not yield as yet, and the victorious legions therefore withdrew from the city and took up their position some miles away on a hill afterwards known as Mons Sacer, or the Sacred Mountain. The Patrician rulers found that the time had come when it was no longer possible to avoid making some concession, and they asked the legions to make known the terms on which they would return to the service of the State. The Plebeians thereupon voted that magistrates should be appointed from the unprivileged orders to protect the interests of the people. There was nothing for it but to yield to these

SCENES IN THE COMING-UP OF ROME

AN EPISODE IN THE LATIN WARS—SABINE WOMEN PARTING THE ROMAN AND SABINE COMBATANTS

THE APPEAL OF THE AGED SENATOR CÆCUS AGAINST A DISHONOURABLE PEACE WITH PYRRHUS

demands. Two Plebeian magistrates, whose number was afterwards increased, designated Tribunes of the people, were appointed, having as their function and their right the protection of the interests of their own order, the power of introducing and vetoing legislation, and of forbidding summary action on the part of the Patrician magistrates.

Law Fixed in Writing. The next important step was to procure a written code, which could not be perverted or misinterpreted at the will of the magistrate. To prepare this code a commission of ten men—*decem viri*—the Decemvirs, was appointed. To them was assigned, for a year, the whole government of Rome, during which time the new code was brought to completion. The code was finally accepted—willingly by the Plebeians, unwillingly by the Patricians. The laws were written on ten metallic tables and set up in the place where the legislative assembly held its sittings.

Tradition asserts that the Decemvirs attempted to transform themselves into a permanent controlling body, headed by one Appius Claudius, whose tyrannical attempts to claim a free-born maiden, Virginia, as his slave caused her father to stab her in order to protect her honour—the story told by Macaulay in the "Lays of Ancient Rome." Popular sentiment was so fiercely aroused that the Decemvirs were overthrown, and government through consuls, Patrician magistrates, and tribunes was restored.

Overthrown Barriers. Laws were passed about this time to ensure the inviolability of the Plebeian as well as of the Patrician magistrates, to prohibit the creation of any magistrate without right of appeal, and to allow of marriage between Patricians and Plebeians. This struck at the very heart of the whole legalised Patrician system, by encouraging marriages hitherto prohibited, and breaking down the barrier between the two orders.

The next great step in the struggle is marked by the Licinian Rogations in 367. The Plebeians had very promptly put forward a demand for admission to the consulship. But, instead of this, military tribunes, for which both orders were eligible, were occasionally appointed instead of consuls. Now, the Licinian law required that one consul should always be a Plebeian. From this time the old strife between the orders vanished. The Patricians became mingled with a new Plebeian oligarchy of wealth, who combined with them in the Senate itself and shared the magistracies with them.

The Drawback of Great Estates. In spite of attempts to check it, the practice continued by which the "public land" rented from the State accumulated in the form of great estates held by a few individuals, and worked largely by slave labour, to the detriment of the free labourers. The Licinian Rogations limited the size of estates, but was soon practically a dead letter. This, however, was felt the less because, with every acquisition of territory, "colonies" of citizens were planted on the soil to serve as a garrison. At the same time many of the best of the yeoman class were consequently removed to a distance from Rome, and could not participate actively in the politics of the great city.

The expanding power of Rome brought her in contact with the Greek colonies of Southern Italy, and, early in the third century, into direct collision with Tarentum. The Tarentines invited to their aid Pyrrhus, King of Epirus, on the eastern shore of the Adriatic Sea, a brilliant soldier who had been taking a hand in the dynastic struggles which followed after the death of Alexander the Great. Pyrrhus came with a considerable army and a large number of elephants. His first battle was long and fierce, and he lost in it a large number of his fighting men; but he won an unquestionable victory, mainly because of the presence of elephants—creatures such as the Romans had never seen before, and against which they did not well know how to contend.

Pyrrhus seems to have well understood the nature of his victory, for tradition reports him to have said that after one other such victory he must have to return to Epirus alone. Some of the Italian states, who were growing jealous of the spreading power of Rome, became allies of Pyrrhus, and encouraged him in his northward

JUNIUS BRUTUS, WHO FOUNDED THE REPUBLIC, CONDEMNING TO DEATH HIS TRAITOR SONS WHO HAD CONSPIRED TO RESTORE THE TARQUINS.

HANNIBAL'S ARMY CROSSING THE ALPS

A SCENE IN THE FAMOUS MARCH OF THE CARTHAGINIANS FROM SPAIN TO ITALY

march. He pressed on to within 20 miles of Rome, but there he found that the Roman preparations for defence were too strong for an attack with his remaining army. He fell back southward, and passed a winter in Tarentum.

The Pyrrhic Truce. Pyrrhus once more measured his strength with the Romans, and was victorious, but at so heavy a cost that he found it necessary to withdraw for another interval to Tarentum, and do his best to restore the strength of his force. A truce was agreed upon between Pyrrhus and the Romans, and Pyrrhus entered upon a new war-like enterprise. He went into Sicily to help the Sicilian Greeks against the Carthaginians, who were now becoming a formidable invading power endowed with a passion for conquest. Pyrrhus had much the same sort of fortune in Sicily as that which he had experienced in Italy. He began splendidly, but after a while received a severe repulse from the Carthaginians—a repulse which seems to have marred his calculations and dulled his hopes of ultimate success.

A Perpetual Fight. The Sicilian Greeks and Pyrrhus did not get on well together, and so after a while he withdrew his forces from Sicily, with the object of again making war upon Rome. A serious mishap came upon him while he was crossing from Sicily to Italy. The Carthaginians attacked him with their navy and destroyed the greater number of his vessels. Pyrrhus was not a man to be discouraged even by heavy losses, and he went on with his attempts at the capture of Rome as if nothing had happened to diminish his military and naval strength. Again, the war god Mars, as would then have been believed, was against Pyrrhus. He sustained a heavy defeat at the hands of the Roman consul, Curius Dentatus, and this ended his efforts to conquer Rome. He had to leave Italy and return to his own kingdom, Epirus, where he arrived with but a very small fraction of the army with which he had set out upon his expedition. The great soldier then renewed his attempts to gain the supremacy in Macedon and Greece, and was ignominiously killed at Argos by a tile flung from a roof. After his death Tarentum was handed over to the Romans, who levelled its fortifications and took possession of its fleet; and before long Rome had completed the conquest of all Italy except the plain of the Po.

The Rise of Carthage. But a new rival in power was looming on the horizon. In the recess of the Bay of Tunis was the city of Carthage, which had been founded, as tradition tells us, by the Phœnicians of Tyre about a century before the building of Rome. The Phœnicians had for centuries been a seafaring race, and had established many ports and stations on all the seas within their reach. They were not warriors, but were animated by the spirit of travel and of commercial enterprise. They were by nature sailors and traders. They now proved themselves capable of brilliant war exploits as well; and, indeed, men who performed such daring explorations of seas hitherto unknown to them could hardly have wanted the courage which makes the soldier. Carthage had long held a footing in Sicily, where she was often at strife with the Greek states—Syracuse and others. In some of these cities rival political factions called upon Carthage, or upon the now mighty Italian power, to aid them, and thus opened the great struggle between Rome and Carthage known as the Punic—that is, the Phœnician—war.

Hamilcar and Hannibal. The war taught Rome that to do battle with a naval power she must have a navy. The struggle went on with varying fortunes, but when peace was at length made Carthage was forced to evacuate Sicily. The ensuing years, however, were spent by the great captain Hamilcar Barca in building up a new Carthaginian dominion in distant Spain, to be the base for a new attack on Rome.

In 218 Hamilcar was dead, but his young son Hannibal had been acclaimed their chief by the forces in Spain. Hannibal deliberately challenged a quarrel with Rome, and in that year set out on the wonderful march in which he carried his army through Southern Gaul, burst through the Alps, and descended upon the northern plain of Italy, where he could count upon the help, or at least the neutrality, of the Gauls. Then he marched towards Rome, and ambushed the Romans on the shore of Lake Trasimenus.

The victory was overwhelming; but Hannibal with his small force could not hope as yet to beleaguer Rome itself. He threw himself into the south of Italy, while he endeavoured to persuade the Italians to accept him as their liberator from the yoke of Rome. But the Italians were stubbornly loyal, although Hannibal won another terrific victory over the Romans at Cannæ.

Rome's Rally. The dominant faction in Carthage did not support their brilliant captain. Possibly the morale of his forces was hurt by their luxurious winter quarters at Capua, as Roman tradition declared. Even Cannæ did not really open the way for Hannibal to Rome. The Roman generals, too, had now learnt that it was their true strategy to avoid pitched battles with their brilliant opponent, and to keep him cooped up in the south.

Hannibal began to see that the resources of the Romans were far greater than he had supposed them, and that the moment one Roman army was defeated, with whatever amount of loss, another Roman army as large, or larger, was soon in the field. He found also that many of the Italian states which had been subdued by Rome were now rallying to her side against the foreign invasion, and were daily rendering his ultimate success more and more difficult. His military strength was becoming gradually diminished, and his own people at home seemed little inclined to continue to send him men and supplies enough to give him any hope of ultimate victory. His hopes now depended upon the arrival in the north of a fresh army from Spain under his brother Hasdrubal. But Hasdrubal on his arrival was caught and crushed by a brilliant movement of the Roman general Nero at the battle of the Metaurus, which was, in fact,

the decisive stroke of the war. Hannibal now gave up hope of offensive operations, and his only purpose was to maintain himself in a mountainous region, and there await the possibility of events. The fact that he was enabled to hold his ground for nearly four years proves how much the military strength of Rome must have been diminished by so many battles. But Hannibal knew well that the interval of comparative cessation from great military operations on both sides was only giving to the Romans all the better opportunity for organising new armies, and marshalling them to the defence of their country.

The Romans were now preparing to turn the tide of war by the invasion of Carthage, and Hannibal had to cross over to Africa in order to resist the invasion. A great battle was fought at Zama, in Carthaginian territory. The Roman army was commanded by Publius Cornelius Scipio, who after this bore the title of Africanus. He had already accomplished the overthrow of the Carthaginian power in Spain and Sicily. Now he shattered the inefficient troops with which Hannibal had to face him. The victory was decisive; Carthage lay at the mercy of the invaders, who dictated terms of peace, which left her virtually helpless, in 202 B.C.

Rome was now not only supreme in Italy; she was mistress of the seas, and the overthrow of Carthage had practically given to her Spain, Sardinia, and Sicily, and a paramount control of the Mediterranean littoral of Africa. She had become an imperial power with great territorial dominions beyond the seas. The next seventy years witnessed not only the establishment of her power in the West, but its expansion in the East.

Macedon, under the dynasty which had been established after the long struggles which followed the death of Alexander the Great, dominated Greece, though most of the Greek cities were still nominally free. The house of the Seleucidæ, the descendants of Seleucus, one of Alexander's generals, ruled over Syria from the Euphrates to the peninsula of Sinai. The Ptolemies, descendants of another of Alexander's generals, ruled in Egypt. Before the end of the Punic war Philip of Macedon had challenged Rome. Almost immediately afterwards Rome attacked Philip, posing as the liberator of the Hellenes. Philip was overthrown at the battle of Cynoscephalæ, and the Roman general proclaimed the liberation of Greece.

THE TERROR OF MASTERFUL ROME—THE SELF-INFLICTED FATE OF THE SENATORS OF CAPUA AT ITS SURRENDER IN 210 B.C. By permission from Mr. Thomas Spence's famous painting "Passing Round the Poisoned Cup."

Then Antiochus of Syria, stirred up by the fugitive Hannibal, challenged the new western power, but was defeated at Thermopylæ and Magnesia, and the great Carthaginian died by his own hand. Macedon was now annexed by the Romans, who thus became virtually the paramount power in Greece. An excuse was found for finally blotting out Carthage in the third Punic war. The subjugation of Spain was completed, and the plain of the Po in Italy, with its Gallic inhabitants, as well as the south-eastern corner of Gaul—namely, France—were made into Roman provinces under the names of Cisalpine and Transalpine Gaul. In the year 136 B.C. Attalus, King of Pergamus, on his death left his kingdom to the Romans, who thus obtained their first actual territorial footing in Asia.

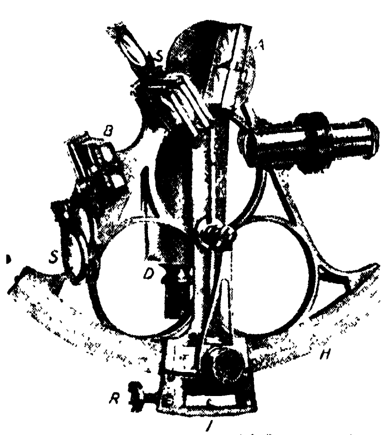
Explanation of the Sextant. Artificial Horizon and the Station Pointer. Observations of the Tides and the Use of Floats.

MARINE SURVEYING

It is not proposed in this article to refer to deep-sea soundings and other special works of an allied nature, but to confine the subject to that which comes within the province of a civil engineer.

Some of the instruments that have already been described in Land Surveying are also used in marine surveying. There are, however, several instruments which will be explained before proceeding with the "field" operations.

The Sextant. This hand instrument [63] is very useful for measuring both vertical and horizontal angles up to 120°. Its construction is as follows: A mirror (A), called the *index glass*, is fixed to an index arm (I), which carries a vernier that reads on the graduated scale (H), and from it the values of the observed angles are obtained. Any movement of the index glass throws a reflection into another mirror (B), called the *horizon glass*. The latter is rigidly fixed, the lower half of the glass being silvered and the upper clear. Thus, a ray of light coming from the direction of N [64] passes through the clear portion of the glass B, down the telescope, to the eye. A ray from the direction of an object at O strikes the mirror A, is reflected to M, and then, through the telescope, to the eye. Therefore, through the telescope come rays both from the direction of N and O, each set forming a perfect image. By operating the index glass (A), images will appear to be moving over each other until the two under observation appear and approximately coincide. The index arm is then clamped by a screw, the tangent screw R being used for the final adjustment of the objects until their coincidence is perfect.



63. SEXTANT

The angle between the two objects can now be read. A small magnifying glass (M) is provided to assist the observer in reading the vernier. Smoked or tinted glasses (S) of various shades are provided for use in strong light, or when taking observations to the sun.

To determine the altitude of the sun, direct the telescope on to the horizon through the clear portion of the glass B, the instrument being held in the right hand by the handle (D). Unclamp the index arm (I) and bring the reflection (made by the mirror A) of the sun on to the silvered portion of the glass B. Clamp and adjust the index arm, as previously explained, so that the top limb of the sun coincides with the line of the horizon, then read off the value of the angle in the usual manner.

The Sextant at Sea. When measuring the altitude of an object above the "sensible" horizon with the sextant at sea, a correction must be made to allow for the "dip" of the horizon—*i.e.*, its apparent angular depression below a truly horizontal line traversing the eye of the observer. The amount of this correction is uncertain owing to the variable refractive power of the atmosphere. Rankine gives a formula for finding the value of the correction:

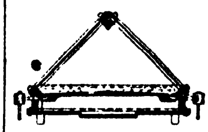
$$\text{Dip in Seconds} = \tfrac{9}{10} \times 206264''\!\cdot\!8 \sqrt{\frac{2h}{r}}$$

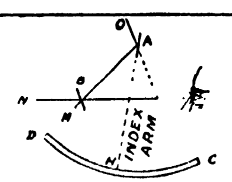
$$= 57''\!\cdot\!4 \sqrt{h} \text{ in feet.}$$

When h = height of observer's eye above the sea

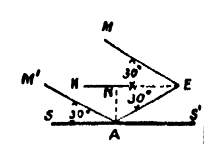
r = radius of curvature of the surface of sea.

Before leaving the description of the sextant it will be necessary to explain an instrument called the "artificial" horizon, which is commonly used in connection with the sextant.


65. ARTIFICIAL HORIZON



64. ARRANGEMENT OF MIRRORS IN SEXTANT



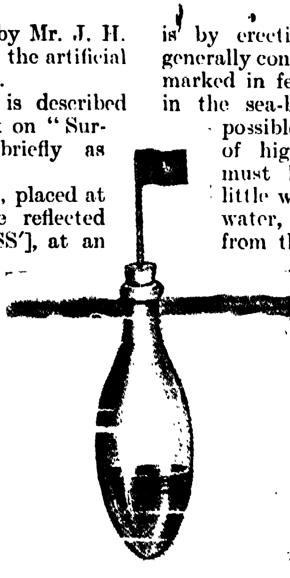
66. ANGLES OF REFLECTION

Artificial Horizon. The angles observed with the sextant at sea are measured from the *sensible* horizon, which, however, is not always possible on land, therefore an "artificial horizon" is necessary. The most suitable form of artificial horizon is that consisting of a tray of mercury having a glass cover or roof. The

illustration [65] shows one made by Mr. J. H. Steward. The angle observed with the artificial horizon is double the actual angle.

The theory of the instrument is described by Mr. W. F. Stanley in his book on "Surveying Instruments," and is briefly as follows.

A small luminous body [66, M′], placed at a distance will have its image reflected from a level reflecting surface [SS′], at an angle equal and opposite to the incident ray, the angles M′AS and EAS′ being equal. Let E be the place of the eye or the sextant. This will receive an image from the distant body M′, sensibly parallel with M′A in ME. The angle MEA will therefore be double the angle of incidence M′AS; the half angle produces the horizontal line EH (provided the plane of reflection SS′ is level). Therefore, if we take half this angle MEA, as it appears in the sextant, it will give an angular position of the object in relation to the horizon at the height of the eye, or be tangential to the surface of the earth. If M′AS be 30°, the angle AEM will be 60°, showing the elevation of the object to be half this angle—that is, 30°. The sextant takes angles up to 120°, therefore 60° will be the limit of meridian altitude that the artificial horizon will measure.



67. BOTTLE F

Tides. It is necessary for the purposes of some marine surveys to take careful observations as to the set of the tides. It will be impossible in this course to deal exhaustively with all the peculiarities of tides, but a few brief observations are necessary in order that some general information may be conveyed. Complete records of the tides in any particular locality would involve months of careful observation on account of the variations that take place at different times of the year. In one place the normal number of tides per day of six to seven hours for each rise or fall will often differ from another place which will have tides of longer or shorter duration. The reason of the varieties in the motion of tides is due to several causes, the height of the barometer being one. It is found that a high barometer accompanies a low tide and a high tide synchronises with a low barometer.

The relative positions of the sun and moon, the direction of the wind and the conformation of the land affects the tides; it is the two last that produce the greatest irregularities. The method employed for gauging the rise and fall of tides, when no pier, wharf, etc., are available, is by erecting a *tide-pole*. These poles are generally constructed out of an old spar, properly marked in feet, and firmly weighted and fixed in the sea-bed in the most sheltered place possible. To obtain the accurate time of high and low water, observations must be taken every few minutes, some little while before and after high and low water, the exact time being calculated from the results thus obtained.

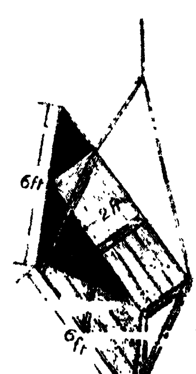
The direction of the tide must be obtained by float observations, as explained later.

It must not be assumed that because it appears to the eye that the tide is flowing in a certain direction that such is the case. Take for example a tidal river. The land water being of a different specific gravity, and warmer than that of the sea-water, will flow over the incoming tide, thus producing two distinct currents in opposite directions. This peculiarity is of extreme importance to engineers, and it is only by careful float observations that the true direction of currents can be obtained.

Floats. The direction of currents can be accurately obtained by using various forms of floats. The action of the wind on the exposed surface of a float which projects too much from the water may cause it to travel in a direction totally different to that of the current. Therefore a float must be made so that as little surface as possible is exposed to the wind. A simple and useful form of float may be constructed from a bottle, as shown by the illustration [67].

Where it is necessary to determine currents at considerable depths a float constructed as shown by 68, or something similar, must be employed.

The method of determining the position of a float from time to time is similar to that explained hereafter when dealing with the location of soundings [70].



68. DEEP-SEA FLOAT

In carrying out a marine survey on a coast line, the configuration of which has been obtained by triangulation (such as shown in 69), the method to be employed must to some extent depend on local circumstances. The nature of the sea-bed must be examined either by diving operations or by borings, the results of which should be noted on the plan, or chart, by reference letters, such as "r" for rock, "s" for sand, "m" for mud, and so on.

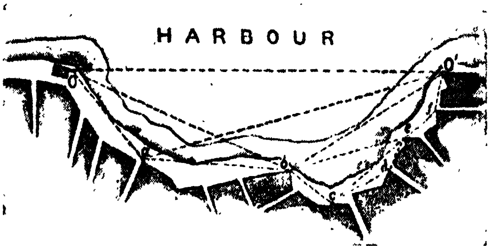
All moorings, buoys, beacons, groynes, lighthouses, prominent rocks, etc., should be clearly and accurately shown. The bed of the sea is surveyed by *soundings* taken from a boat with a loaded line. All

soundings on published charts are given (in fathoms) for low water at ordinary spring tides.

The position of each sounding can be obtained either by angular measurement from the shore to the boat or from the boat to the shore.

The following is a description of the first method :

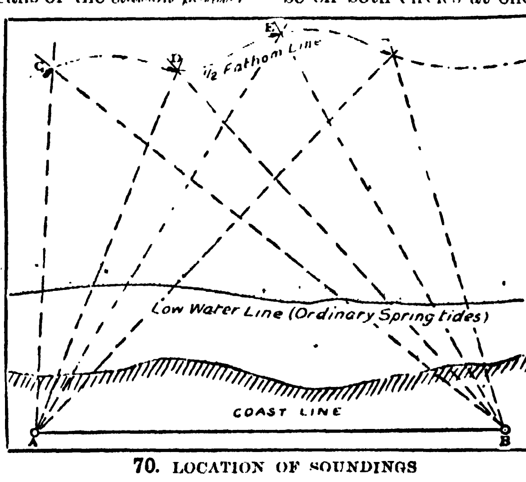
Set out on the shore a base line [70, AB] of known length and position with regard to the chart or plan. At A and B set up theodolites. The observers follow with the telescopes of the instruments the movements of the boats from which the soundings are being taken. On receiving a prearranged signal from the boat, each attendant observes the angle between the boat and the base line, thus locating that particular sounding. The time also is noted. These angles can also be obtained, when minute accuracy is not required, by employing prismatic compasses or box sextants. From the angles thus obtained at the stations A and B, the position of each sounding (as shown by the points C, D, E, and F on the illustration) can be determined and plotted on the chart or plan by means of a protractor.



69. HARBOUR SURVEYING

A better and more convenient method of obtaining the positions of the soundings is by taking observations from the boat with the sextant, and then by means of the *station pointer* they can be plotted directly on the chart. The following description will explain the whole operation.

The Station Pointer. The illustration [71] shows the arrangement of this useful instrument, which is employed, as already stated, for plotting on a chart or plan the position of a boat from which angular observations have been taken with the sextant to three well-defined points on the shore, the positions of these points being known. The form of the instrument is that of a circular metal protractor with three arms radial to a common centre (S), one fixed (A), and two movable. The movable arms are provided with verniers and screws. The theory of the instrument is based upon the 21st proposition of Euclid, Book III., which shows that the angles subtended by the chord of the segment of a circle measured from any point in the circumference are equal.



70. LOCATION OF SOUNDINGS

Thus, if the angle [72] between A and B is observed to be, say 60°, the observer knows that he is somewhere on the circumference AEDB, on any part of which, as at E or D, the angle subtended by AB will be the same. The measurement, therefore, of an angle between two objects gives this information—that the observer is on the circumference of a circle which passes through two objects, the diameter of which varies according to the angle, with an equal length of AB. This will be seen by comparing 72 and 73. In the former, AEB = 60°, and in the latter, AGB = 30°. Therefore, for example, if a mariner finds that a rock exists at X, and two well-defined objects exist at A and B, he has only to take care that the angle measured between them is considerably smaller than that measured at X [73], which may be taken from his chart, to ensure his passing outside its position.

The Three-point Problem. To find the precise position of the boat two angles must be taken [75]. This is called the "Three-point Problem." It is evident that where two circles cut one another is the observer's position, for though he may be at E [74], so far as his angle between A and B is concerned at that position, the angle observed between C and F will not agree, nor will such agreement be found unless the observer is on the circle CDHF. He can only be on both circles at once when he is at D.

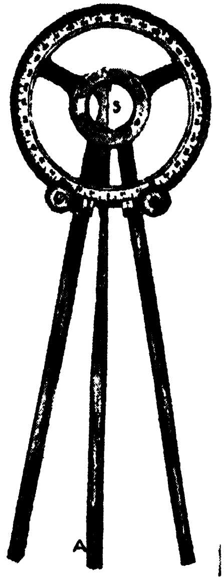
Suppose that instead of taking the objects CF to measure the second angle, we take it between BC [75], the observer must be at the point D for the same reasons. The observations can be plotted by means of circles, or more rapidly by using the station pointer in the following manner. Set the angle ADB off on one side of the fixed arm, and the angle CDB on the other side. Place the instrument on the chart so that the fixed arm is directed to B, move the instrument about on the chart till the other arms fall on the points A and C. The centre (S) of the instrument must then be the required position, and is pricked on to the chart. If the points ABCD fall on the circumference of one circle, the point is indeterminate.

The Lords Commissioners of the Admiralty have issued a pamphlet on the station pointer which deals exhaustively with the subject.

Soundings must be reduced to a known datum in order to connect the level of the sea-bottom

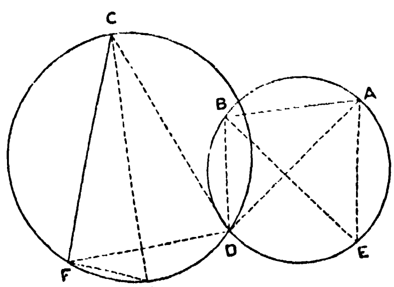
to that of the shore. Soundings of equal values are usually connected together by dotted lines, as in contours on land, the value of the contour being indicated by the dots. Thus, a four fathom contour would be shown by four dots, then a space, and so on Care must be observed in connecting the soundings together, otherwise shoals, or sandbanks may appear on the chart where none in reality exist.

Foreshore Survey. The survey of the foreshore above low-water mark is carried out in the same way as land surveying. The levelling operations should be extended to, and even below, low water by the staff-holder wading into the sea. The levels so obtained are more accurate than those taken by soundings. Should the work have to be carried out at night, the cross hairs and staff require illuminating, which may be done in the following way: A mirror is soldered to the top of the cap of the telescope in such a position that it projects downwards over the object-glass, making an angle of 45° with the horizontal axis of the instrument. An elliptical hole is cut in this mirror. A lantern supplies the light, which is reflected on to the cross hairs. The staff can be illuminated by a torch, and is thus easily observable through the elliptical hole in the mirror.

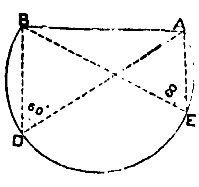


71. STATION POINTER

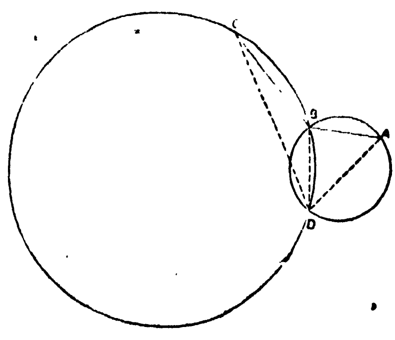
Base by Sound. The length of a base line can be obtained by sound. Although this method is not accurate, it may be employed when only approximate measurements are necessary. It consists in taking the interval of time which elapses between the *sight* of a flash from a gun and the arrival of the *sound*, the observer being at one end of the required base line and the gun at the other. It is preferable to have both a gun and an observer at each end of the line taking alternate readings. The time should be taken by chronometer watches, the beats of which are recorded by the ear and not by the sight, the number per second being thus accurately obtained. The chronometer is held to the ear and the beats counted as nought, nought, etc., until the flash is observed, and then one, two, three, etc., until the report is heard. The mean time of a number of observations, arithmetically obtained, is not correct on account of the acceleration when travelling with the wind being less than the retardation when travelling against it. The following formula must be applied:



74. INDETERMINATE POINT



72. EXAMPLE 1



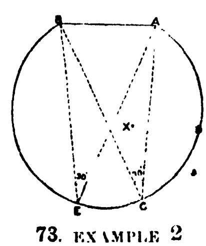
75. THREE-POINT PROBLEM

$$T = \frac{2tt^1}{t + t^1}$$

when T = mean interval required; t = interval observed one way; t^1 = interval observed the other way. The mean time (T), multiplied by the velocity of the sound for the temperature at the time of observation, will give the distance between the two places.

Sound travels at the rate of 1,090 feet per second at 32° F., with an increase or decrease of 1·15 feet per second for each degree of rise or fall in temperature.

Synopsis. The point which we have reached marks a definite stage in our study of civil engineering. This chapter concludes the teaching of Surveying, except for the references which we shall have occasion to make in describing the constructional part. The scheme of our treatment to follow may be indicated. The next chapter describes the history and practice of the Ordnance Survey, with information regarding the value of the different scales for different purposes. The procedure usual and necessary in seeking to obtain parliamentary powers for public and private works explained in detail. Then we proceed to study the practice of civil engineering. The course concludes with a description of civil engineering abroad, and the diverse influences, such as climate, labour, transport facilities, etc., which modify the practice from that usual in this country are considered.



73. EXAMPLE 2

HENRY ROBINSON

The Dramatic Poets—continued. Ben Jonson, Beaumont and Fletcher, and the Contemporaries of Shakespeare.

POETRY OF THE ELIZABETHAN AGE

THE greatness of Shakespeare could not be better illustrated than by contrast with BEN JONSON (b. 1573; d. 1637). In almost any age Jonson would have been accounted a writer of the most extraordinary parts. His scholarship was profound—indeed, Shakespeare's learning is, by comparison, almost superficial—but in all his serious efforts to produce a dramatic work of the highest he gives evidence of scholarship only, and not of that divine, ineffable "something" which makes the poetry of Shakespeare as harmonious a part of the world's intellectual life as seed-time or harvest is of its physical life.

It is hard to determine how Jonson came by his learning, as we have evidence of only a few weeks spent at St. John's College, Cambridge, in his sixteenth year, after leaving Westminster School. In his youth he had to work for a time, to his never-forgotten disgust, at bricklaying, and he was a soldier in the Low Countries when only eighteen years of age. It has been asserted that at nineteen he returned to Cambridge, and completed his studies, but this theory rests rather on the desire to explain his wonderful knowledge of the Latin poets than on any direct evidence. He was as injudicious as his great contemporary in contracting an early marriage, and perhaps poverty, as much as inclination, led him to become an actor, but he did not reach the position in the profession attained by Shakespeare.

Steeped in the works of the pagan poets, his native genius was undoubtedly more lyrical than dramatic in inspiration, though he gives evidence of a certain saturnine temper which, inclining to tragedy, but modified by the former impulse, expresses itself in satire. It was with a comedy, however, that he first attained success on the stage, and "Every Man in His Humour," produced in 1596, and performed two years later by the company of which Shakespeare was a member, secured a popularity which led to his following it with the play, "Every Man out of His Humour."

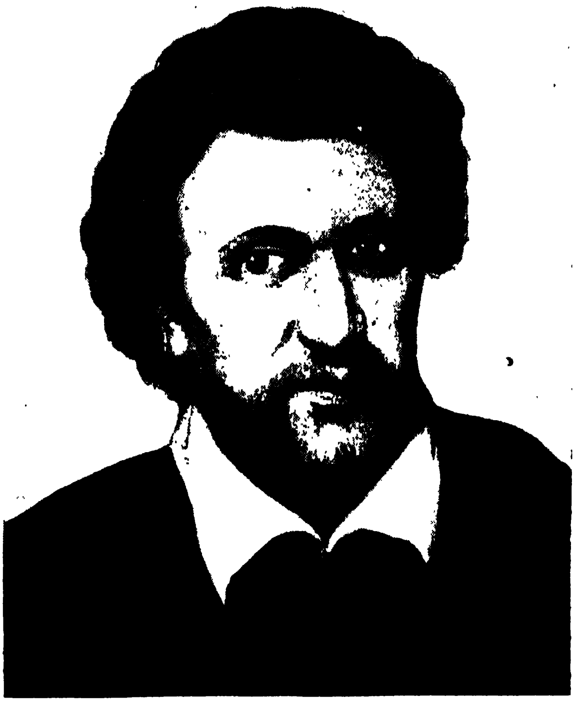
Both are admirable comedies, and, like his two tragedies, "Sejanus" and "Catiline," follow classical models; but the author is so obviously subjected to the strict rules of classical composition that his work lacks spontaneity and natural grace in the comedies and tenderness in the tragedies. This is the fault of all his plays: they are overlaid with the weight of his learning; made coldly accurate by the careful observance of his models: and neither in tragedy nor in comedy does he sound the depths of human emotions. Though the character is always perfectly observed and represented, he does not take us to the hidden springs, as Shakespeare does, not so much by art as by intuition, even in his lesser works. For these reasons Jonson's dramatic works, though well known in his time, have ever since been dead to all but students of literature. "Every Man in His Humour" has occasionally been revived on the stage, but never with lasting success.

Such prosperity as Jonson enjoyed came from the composition of masques, which were a favourite amusement of the Court and the aristocracy. The masque is a form of stage entertainment midway between a pageant and a play. It may be said to have been originated by the introduction into royal processions of masked, or disguised, persons representing allegorical or fictitious characters. This developed into entertainments resembling the tableaux vivants, still popular, in which Henry VIII is known to have delighted.

Under Elizabeth the masque rose into extreme popularity, and most of the dramatists, with the notable exception of Shakespeare, set themselves to supply their lordly patrons with such entertainments. They were written both in prose and verse, the dialogue being interspersed with songs, and afforded opportunities for the display of gorgeous costumes and scenic decoration quite foreign to the stage of the time, where no attempt was made at scenic effect or accuracy of "make-up." Ladies also took part in these private theatricals, whereas

on the stage all the feminine parts were discharged by boys or young men. The finest example of this class of poetic composition is Milton's "Comus." In it the masque, as an acted entertainment, may be said to have culminated, for it died out under the Commonwealth and has never been revived.

Some of the best specimens of Jonson's verse are to be found in his masques, but his exquisite little song, "Drink to me only with thine eyes," is one of fifteen lyrics in a collection entitled "The Forest," published in 1616. Jonson, in his personal character, had some traits which suggest likeness with his great namesake of the eighteenth century, and "rare Ben" anticipated Samuel's satirical treatment of the Scots, as he came near to having his ears clipped for making fun of King James's countrymen in "Eastward Ho," a drama in which he collaborated—a rare thing for him, as he was vain of personal achievement—with Chapman, Marston, and Martin. He died on August 6, 1637, having experienced loss of friends and favour in his later years. His gravestone, in Westminster Abbey, is inscribed, "O Rare Ben Jonson."



BEN JONSON
From the portrait by Gerard Honthorst

Reference has been made to Jonson's collaborating with other dramatists. This was a favourite method of work among the Elizabethans, as it is in our own time with the French dramatic writers. But the most noteworthy example of collaboration was furnished by Beaumont and Fletcher, who were so intimately associated in their lives that they had house and clothes in common. Both were of gentle birth, scholars, and men of genius. Their plays—chiefly comedies—were even more popular than Shakespeare's, being, if anything, more in harmony with the temper of the period. FRANCIS BEAUMONT (b. 1584; d. 1616) probably became acquainted with his friend JOHN FLETCHER (b. 1579; d. 1625) at the meetings of the celebrated Mermaid Tavern, frequented by Shakespeare, Jonson, and the wits of the time, as celebrated by Beaumont in his verses to Jonson:

"What things have we seen
Done at the Mermaid! heard words that have been
So nimble, and so full of subtle flame,
As if that every one from whence they came
Had meant to put his whole wit in a jest,
And had resolved to live a fool the rest
Of his dull life."

The dramatic writings of this famous pair are full of fancy and of bright pictures, though there is no denying the "studious indecency" in which they reflect, more racily than need be, the manners of their age. Fletcher had probably the greater share in the composition of the plays which bear their joint names, and alone he wrote at least twenty, Shakespeare being thought to have collaborated with him in "The Two Noble Kinsmen," while Fletcher also had a hand with Shakespeare in the writing of "Henry VIII." It is hard to differentiate between Beaumont and Fletcher, though it seems easy enough by comparing their individual and their joint productions; but perhaps it is not wrong to say that the one had a more strongly marked lyrical gift, while the other was essentially dramatic. Both men were immensely popular with their contemporaries and theirs will ever remain among the great names of Elizabethan drama.

By way of summing up their characteristics we cannot do better than quote this comparison from the poet Campbell's "Specimens of the British Poets": "There are such extremes of grossness and magnificence in their dramas, so much sweetness and beauty, interspersed with views of nature either falsely romantic or vulgar beyond reality; there is so much to animate and amuse us, and yet so much that we would willingly overlook, that I cannot help comparing the contrasted impressions which they make to those which we receive from visiting some great and ancient city, picturesquely but irregularly built, glittering with spires, and surrounded with gardens, but exhibiting in many quarters the lanes and haunts of wickedness. They have scenes of wealth and high life, which reminds us of courts and palaces frequented by elegant females and high-spirited gallants, whilst their old martial characters, with Caractacus in the midst of them, may inspire us with the same sort of regard which we pay to the rough-hewn magnificence of an ancient fortress."

We must now briefly dismiss many names, though most of them are almost as worthy of some detailed notice as Beaumont or Fletcher. PHILIP MASSINGER (b. 1583; d. 1639), who was laid in the same grave as Fletcher, at St. Saviour's, Southwark, was so variously associated with Fletcher and other dramatists in play-writing that it is difficult to form an estimate of his individual work. But he is certainly no less gifted in comedy than Beaumont and Fletcher, and in tragedy he displays real power. His only play that has held the stage is "A New Way to Pay Old Debts," a brilliant and mordant comedy.

JOHN FORD (b. 1586) was a dramatist of real tragic power, to whom only the darker emotions of the heart seemed to appeal, for his plays are sombre and unredeemed by the finer feelings of fancy and imagination. His "Perkin Warbeck" is a good historical drama, and "'Tis Pity——" is a remarkable tragedy. He collaborated in several plays with THOMAS DEKKER (b. 1570; d. about 1641), a prolific and able writer, both of tragedy and comedy, who in turn was associated with JOHN WEBSTER, of whose life hardly anything is known. Webster was a dramatist of extraordinary power in tragedy, and over his works gloom, profound and chilling, seems ever to brood. "The Duchess of Malfi" is his greatest play, and must rank with the finest of the period; but it is easy to understand how he had scant favour from contemporary audiences.

THOMAS MIDDLETON (b. 1570; d. 1627) wrote many charming comedies, while WILLIAM ROWLEY (b. about 1585), an actor-playwright of no remarkable qualities, collaborated at various times with the five last-mentioned dramatists, and also with THOMAS HEYWOOD, who had a large share in the writing of 220 plays up to the year 1633, and is believed to have lived until 1648. "A Woman Killed with Kindness" has real pathos and simplicity to distinguish it, and may be accounted the best of Heywood's plays. JOHN MARSTON (b. 1575; d. 1634), was a poet of most unequal achievement, associated with Jonson and GEORGE CHAPMAN (b. 1559; d. 1634) in the production of "Eastward Ho," as noted above. Chapman was greater in comedy than in tragedy, "All Fools" being an excellent play of the former class, while his tragedies are usually marred by bombast and fustian. His great achievement was the translation of Homer's "Iliad" and the "Odyssey" into rhymed verse of fourteen syllables. These translations, despite numerous faults, are in many ways unsurpassed by Pope's more familiar versions of the same works, and are well worthy of attention.

With JAMES SHIRLEY (b. 1596; d. 1666) we reach the last of this school; for, though he was but a boy when the reign of the virgin queen ended, his early associates were the later Elizabethans, and all the influences on him were Elizabethan; he had come to manhood at the time of Shakespeare's death. Charles Lamb says of him: "James Shirley claims a place among the worthies of this period, not so much for any transcendent talent in himself, as that he was the last of a great race, all of whom spoke nearly the same language, and had a set of moral feelings and notions in common. A new language and quite a new turn of tragic and comic interest came in with the Restoration." This, rather than Campbell's somewhat perfervid panegyric of the dramatist, is a proper view of Shirley, for while the tragic and pathetic passages of his plays, which are chiefly tragi-comedies, are often distinguished by great tenderness and true feeling, he fails on the whole to rise to the level of his models, Beaumont and Fletcher and Ben Jonson.

We have now reached the end of an important stage of our study, for on our knowledge of, and sympathy with, the poets from Chaucer to Shirley will depend much of our understanding of English Literature. The Elizabethans, especially, are the beacon lights of the English spirit, if the metaphor will pass. To know them well is to have the whole character of England illumined for our better appreciation. They represent more directly than any body of writers in England, before or since, the spirit of their time and country. This may be thought an over-statement, when we remember how the spirit of the eighteenth century is reflected in writers of the period. But that is not the real spirit of England; it is a passing phase; whereas the spirit of the Elizabethan age is no passing phase, but the very pulsing of England's heart.

In a sense, the Elizabethans are more "in touch" with us of this later day than are the writers of the eighteenth century. We shall even find that the literature of the Victorian age—rich to abundance though it is in great writers and in great works—is not so thoroughly in tune with the English spirit as is that of the Elizabethan age, for the creators of the latter were poets to a man, and the poet is ever the truth-teller. He is not so apt to temporise with passing moods and whims as the prose-writer is; he utters himself with greater freedom, fearless, because "It is in me, and shall out." Thus the age of Elizabeth remains for ever the epoch in which—with the awakening of all those varied energies that have since made the British Empire the unmatched wonder of the world's history—there lived, surely by no mere chance but inevitably, a splendid company of poets whose poetry enshrines for all time the English spirit—patriotism, heroism, idealism, the love of liberty, beauty, Nature, domesticity.

That the Elizabethan poets were as capable of expressing grossness as of voicing the noblest aspirations is no argument against them. Every country has its standard of good taste: an ocean wider than the Atlantic separates the English of today in matters of taste from their nearest neighbours across the Channel. And every age of any one country has had its own standard of good taste. That of the Elizabethan was assuredly different from that of our day; just as that of fifty years hence promises to be strangely different from the standard of twenty years ago. The Elizabethan poets—because, for all their superiority to the multitude, they were still men of their time—necessarily reflect in their writings the looseness of their age in the treatment of morals. It does not follow that they were one degree less moral than we are today; but they spoke of subjects which with us it is bad taste to discuss. They were, for that very reason perhaps, the more honest; and sincerity is the infallible test of all enduring literature.

And it is Shakespeare, again, who towers above his glorious company of contemporaries in his comparative freedom from all besmirching elements, but by that token he is, as we have already hinted, really less the mirror of his age—but more the mirror of the English spirit—than, for example, Beaumont and Fletcher. He is the most modern writer in our language. It would seem that in one fruitful moment the genius of England gave birth to a poet who interpreted his country to itself and to the world once and for all time, his thought and language being the everlasting mind and utterance of his race at the highest.

We may take leave of the Elizabethans by quoting the summary with which Taine begins his study of the theatre in his "History of English Literature."

"Forty poets, among them two of superior rank, as well as one, the greatest of all artists who have represented the soul in words; many hundreds of pieces, and nearly fifty masterpieces; the drama extended over all the provinces of history, imagination, and fancy—expanded so as to embrace comedy, tragedy, pastoral and fanciful literature—to represent all the degrees of human condition, and all the caprices of human invention—to express all the perceptible details of actual truth, and all the philosophical grandeur of general reflection; the stage disencumbered of all precept and freed from all imitation, given up and appropriated in the minutest particulars to the reigning taste and public intelligence: all this was a vast and manifold work, capable by its flexibility, its greatness and its form, of receiving and preserving the exact imprint of the age and the nation."

Such is the Elizabethan drama, the most important of all periods of English literature, not to the student only, but to the general reader who desires to possess a knowledge of our great literary heritage.

J. A. HAMMERTON

**The Most Responsible Post in the Municipal Service.
Qualifications and Salaries. Clerks of County Councils.**

THE TOWN-CLERK

There is a marked and increasing tendency among local authorities to restrict applications for the position of town-clerk to members of one or other branch of the law. And this is not a matter for surprise.

What the Town-clerk must Know. The town-clerk's is the foremost, and undoubtedly the most difficult, position on the municipal staff. Yet, with all its responsibilities and worries, the possibilities it offers are greater—and earlier attainable—than in any other branch, certain engineering posts alone excepted. The town-clerk is the adviser to his council on innumerable points of law, fact, and practice—in itself no light office, having regard to the multiplicity of important activities carried on by a progressive borough and the scarcely avoidable ignorance of many of the councillors concerning them. He controls a busy department of his own, and is also the official head of the whole staff and the responsible officer for the due execution of the council's orders. At the meetings of his authority, he is the chairman's right-hand man ; and having familiarised himself with the details of every important scheme and proposal when he has not framed them himself—is in a position to advise upon these as they are raised.

Director-in-General of the Town's Affairs. The acquirement of property and extension of municipal works, "slum area" clearances, and the adoption of statutory powers —on such grave matters as these his judgment is of great weight. His store of law, routine, and precedents must be always at his finger-tips, as it were, for the services of the various heads of departments who constantly consult him. He must be able to draft new by-laws and regulations as need arises, and to handle adequately his council's case at a Local Government Board inquiry, or before a parliamentary commission. An expert within his own particular province, and a point of focus generally between the council and its staff, the town-clerk needs to blend the qualities of the specialist with those of the tactful and patient administrator.

Salaries of Town-clerks. In respect of remuneration, the town-clerk's lot is indeed a happy one. As chief staff officer, he generally enjoys the largest salary on the pay-list. The actual range of payment may be readily illustrated by a few typical appointments, which in some instances include special duties in addition to those of town-clerk.

In the City of London this officer's salary is £3000, and such leading corporations as Manchester and Glasgow pay their town-clerks £2000 a year. In the London boroughs salaries vary generally between £1000 and £1250. Other figures are as follow, the initial salary alone being given in certain instances.

Newcastle	£1500
Leicester	£1500
Bolton, £650, rising by £50 annually to	£1000
Burnley .. ..£700 to	£900
Tynemouth .. .. ..£600 to	£800
Exeter	£675
Ayr	£500
Ramsgate, £400, rising to..	£600
Bexhill, ..	£400

Private practice is, in most of these instances, debarred by the terms of the engagement. Where the appointment is not a whole time one, it is almost invariably given to a solicitor, the salaries paid varying from about £100 a year for small district councils, up to £500 or more for the boroughs, and the person appointed having to provide his own offices and staff. High salaries, in this branch of the service at least, are not confined to the foremost authorities, boroughs of quite moderate importance paying their chief official from £700 to £1000 or so per annum. Such of the posts named as have recently been offered for competition have been usually restricted to admitted solicitors, or, in Scotland, to law agents and Writers to the Signet. The effect of such a proviso is to limit competition, and to render advancement speedy and sure for solicitors of the requisite ability and training.

Qualifications. It will be evident from what has been said of the town-clerk's duties that a wide experience of municipal matters is of even greater importance than a purely legal training. Local government work has special requirements which can only be met by years of practice in a municipal office. But men thus qualified often win leading appointments at an early age.

The town-clerkship to the City Corporation, for example, which is, perhaps, the premier position of its kind in the kingdom, is held by a brilliant lawyer, who when elected was only some 35 years old; yet his previous municipal record included several subordinate positions and some seven years' experience as chief of the Leicester staff. Rochdale, Bolton, Bexhill, and Tynemouth can show appointments which were won at similar early ages.

The Best Beginning. A number of town-clerkships are held by barristers, and many others by non-lawyers; and there is nothing to prevent town councils from making similar appointments in the future. But the tendency to favour professional lawyers—and particularly solicitors—is increasing. A careful study of the careers of many successful town-clerks makes it abundantly clear that, to secure the most

promising start, a candidate should begin his training as articled clerk to a solicitor holding an appointment as clerk to a local authority. To a considerable extent at least the town-clerk is made rather than born; and the formula for success may be expressed as ability *plus* municipal training *plus* professional qualification. A further argument in favour of the last item in this formula may be found in the practice followed by some authorities of combining the appointments of town-clerk and solicitor in one official.

Not a "Close" Calling. The reader must not conclude, however, from what has been said, that town-clerkships form a close preserve, as it were, shut off by a ring-fence from those whose circumstances prohibit their becoming articled clerks in their teens. There is too much wholesome competition in the service to permit of this. A number of men have entered the town-clerk's department as paid junior assistants, and on promotion to the grade of committee clerk, or assistant town-clerk, have shown such aptitude for their work that they have been given their articles under the town-clerk or his deputy while retaining their salaried posts. In this way the defect of a non-professional start is most readily cured; but its achievement is only possible by the goodwill of the council and its chief officer, and is too uncertain a method to be desirable, if articles can be obtained earlier in the usual way. Moreover, as many an overworked official has discovered to his cost, it is extremely arduous and difficult to prepare for professional examinations while occupied all day with the anxieties of a responsible post.

Deputy and Assistant Town-clerks. What has been said on the question of training for town-clerkships renders it unnecessary to discuss at any length the grades from which they are mainly recruited. Assistant and deputy rank are the successive steps by which the majority of principals have ascended to their positions. These subordinate posts are often filled by the promotion of able committee and office clerks, for many of whom they represent the highest positions attainable in the absence of a legal training. On the other hand, a solicitor who has served his articles in a municipal office seldom has any difficulty in obtaining, as soon as he is admitted, either an assistant town-clerkship in an important borough or a deputyship in a smaller one. His salary in either event will probably begin at £150 or £175, and rise to £300 or £350, with or without the right to practise privately. On securing deputy rank under a busy authority these figures may be doubled at least. Thus, Warrington pays its deputy town-clerk £250 a year, Bolton £350, Bradford £500—rising by £25 yearly to £750. The higher posts, however, are mostly restricted to qualified solicitors. The Bradford appointment mentioned, for instance, is coupled with the duties of assistant solicitor, and was offered under the following conditions: "Candidates must be thoroughly experienced in local government law and practice, and have an intimate knowledge of the work of a town-clerk's department in a large district, including conveyancing and common law, and must also be fully competent to act as advocate in conducting important cases before magistrates."

Clerks to the County Councils. Both in value and in the special training expected of candidates, these posts much resemble town-clerkships, but are naturally far fewer in number. They afford a wide gradation of salary, from the £350 paid by the Isle of Wight to the £2000 with which the County of London rewards its distinguished clerk. It is usual to advertise vacancies inviting applications from solicitors and barristers only. In practice a candidate who was not well trained in the special requirements of county law and administration would have no chance of success for the town-clerk's office. The best training is afforded by a deputyship.

Solicitors to Local Authorities. The solicitor to the City of London receives £2500 a year, and his legal colleague, the comptroller, £500 less. The remuneration of the solicitor to the London County Council, who was formerly its parliamentary agent, begins at £1200, and rises to £1500 a year. In the metropolitan boroughs and larger towns the appointment of solicitor to the council is of an average value of at least £750 a year, and often reaches nearly twice that figure, without restriction as to private business. These latter positions, however, are jealously retained, for the most part, by solicitors of established practice and of considerable local influence, and are therefore attainable only by partnership or succession. Easier of access for the young lawyer without influence is the post of assistant solicitor under a leading authority, such as is occasionally advertised in the municipal press. Manchester pays £550 a year, and Newcastle £400. Under the London County Council, assistant solicitors begin at £150 a year, and may attain a salary of £500 or £750, according to their ability and fortune. Further, the office involves a useful variety of duties, on the strength of which a good many assistant solicitors obtain lucrative town-clerkships.

Other Legal Posts. Omitting High Court and police-court appointments, which belong to the National Section, there remain a host of other municipal offices available only to a solicitor or to "counsel learned in the law." They range through the whole gamut of dignities, from the Recorder of London, with his knighthood and £4000 a year, down to the clerk of indictments on a judge's circuit, earning as many hundreds. The intermediate grades are occupied by county-court judges (£1500 to £2500), registrars (about £800 to £1000), and minor clerks of the peace, and so on, at all salaries. But such posts as these are in their nature legal rather than municipal; they are available only to lawyers of standing, and, moreover, are seldom (if ever) definitely pursued by aspirants from the outset of their professional life.

ERNEST A. CARR

Dr. Benjamin Moore and His Most Recent Experiments. Making the Means of Life.

HOW LIFE MAY BE BEGINNING NOW

In the nineteenth century men tried hard to believe that the "spontaneous generation of life" was disproved, and yet that life *had* been spontaneously generated upon the earth in the remote past. This was a hard doctrine to believe, and probably no one quite succeeded in believing it, for everyone knew that all the conditions to favour the spontaneous origin of life are found today, while in the remote past the conditions cannot have been any more favourable. Dr. Charlton Bastian has persistently pointed this out for forty years, and he has lived to see the force of his argument widely conceded among the younger school of biologists.

But what we need is *evidence*. In the nineteenth century the important fact was that the evidence for the spontaneous origin of life was not forthcoming. On the contrary, all Pasteur's experiments went directly in the other direction. But now we may perhaps make a fresh start. In the opening chapters of this course the utmost prominence has been given to the view that the simplest forms of life which the microscope can reveal, such as microbes and the amœba, are not really the simplest forms of life. We have insisted upon this because the nineteenth century was very confident that these newly discovered forms of life were as simple as life could be. Then, when no evidence of their spontaneous generation could be found, the assertion was made that spontaneous generation was impossible.

When, however, we realise that there must be and are forms of life *vastly* simpler than an amœba or even a micro-coccus, we must refrain from ever again quoting Pasteur's experiments, or any others made in the nineteenth century, as conclusive. We must make new experiments, in the light of our new knowledge. This is now being done, with most important and promising results.

We have already learnt the central place which is occupied by chlorophyll in the making of the living world. By studying the modes of nutrition of the various types of life we have seen that the whole problem of the origin of life turns upon chlorophyll, the only gate by which the energy of sunlight can enter into inorganic matter and, so to say, vivify it. The modern aspect of the problem was very admirably stated by Dr. Benjamin Moore, Professor of Bio-Chemistry in the University of Liverpool, in 1912, in the following words:

"The substance chlorophyll is itself far too complex to arise as a first step from inorganic matter in the absence of life, yet as the present life-builder of the world it gives a clue as to what ought to be sought for in all experimental work designed to discover a bridge over the interval between the inorganic and the organic. The modern problem of spontaneous generation dawns upon us from these considerations. . . . In this manner we can conceive that the hiatus between non-living and living things can be bridged over, and there awakens in our minds the conception of a kind of spontaneous generation of a different order from the old.

"The territory of this spontaneous production of life lies not at the level of bacteria, or animalculæ, springing forth into life in dead organic matter, but at a level of life lying deeper than anything the microscope can reveal, and possessing a lower unit than the living cell, as we form our concept of it from the tissues of higher animals and plants. In the future, the stage at which colloids begin to be able to deal with external energy forms, such as light, and build up in chemical complexity, will yield a new unit of life, opening a vista of possibilities as magnificent as that which the establishment of the cell as a unit gave, with the development of the microscope, about a century ago.

"It was no fortuitous combination of chances, and no cosmic dust, which brought life to the womb of our ancient mother earth in the far distant Palæozoic ages, but a well-regulated, orderly development, which comes to every mother earth in the Universe in the maturity of her creation when the conditions arrive within the suitable limits.

"Given the presence of matter and energy formed under proper conditions, life must come inevitably, just as, given the proper conditions of energy and complexity of matter in the fertilised ovum, one change after another must introduce itself and give place to another, and spin along in kaleidoscopic sequence till the mature embryo appears, and this in turn must pass through the phases of growth, maturity, reproduction, decay, and death.

"If this view be the true one, there must exist a whole world of living creatures which the microscope has never shown us, leading up to the bacteria and the protozoa. The brink of life lies not at the production of protozoa and bacteria, which are highly developed inhabitants of our world, but away down amongst the colloids, and the beginning of life was not a fortuitous event occurring millions of years ago, and never again repeated, but one which in its primordial stages keeps on repeating itself all the time, and in our generation. So that, if all intelligent creatures were, by some holocaust, destroyed, up out of the depths in process of millions of years intelligent beings would once more emerge."

This long quotation from Professor Moore's work on the "Origin and Nature of Life" should be read and re-read with care, because it seems not unlikely to take a historic place in the advance of our knowledge concerning one of the deepest and most fascinating problems in all science. If there were nothing in the way of experiment to add to Professor Moore's speculations little more than a year ago, perhaps this would not be the place to quote them, but since his words were written he has set to work on the lines laid down by himself, and has already reached some results which promise to be of the first importance, and which must now be studied.

In our last chapter we found ourselves faced with the two propositions, "No chlorophyll, no life," and "No life, no chlorophyll." But what if we can find anything which might act like chlorophyll, using sunlight, as it does, but which could come into existence without the action of pre-existing life? If we could find such a thing, it might furnish a really "spontaneous" beginning of life. The search for such a substance was the task which Professor Moore and his assistant, Mr. T. A. Webster, set themselves. In a paper received by the Royal Society in June, 1913, and subsequently read at the International Physiological Congress, these workers have given us the first results of their remarkable inquiry. The full title of the paper is as follows, and the one unfamiliar word will soon be quite familiar to the student: "Synthesis by sunlight in relationship to the origin of life: synthesis of formaldehyde from carbon dioxide and water by inorganic colloids acting as transformers of light energy."

The unfamiliar and all-important word here is *colloid*. It was introduced into science half a century ago by a great investigator, Thomas Graham. It literally means *glue-like*, and we may think of colloids as things which rather resemble glue in their physical properties. Graham taught us to contrast colloids with crystalloids—substances which were *not* glue-like, but like crystals, say of common salt, and which, when dissolved, formed clear solutions which would travel anywhere. But glue does not form a clear solution, and even when we melt it in water it will not "mix," as the solution of a crystalloid will. Now, living matter in general is made up essentially of colloids. Chlorophyll itself, for instance, is a colloid, and so are all the ferments which we have already had reason to study.

The chemistry of the colloids is a very obscure and difficult subject, about which chemists themselves are as yet in extreme disagreement, and which cannot be discussed here; but the great point for us is to realise that colloids have certain peculiarities which may be summed up in the word *unstable*. They are made of very large molecules (see CHEMISTRY), so large that they are always tending to break down; they are intensely sensitive to external influences, *such as light*; and it is this extreme instability, which we may almost call sensitiveness, of the colloids that accounts for the behaviour of living matter, which is essentially made of colloids and of nothing else.

The colloids found in living cells were made by them, and therefore they cannot furnish us with the key to the origin of life. But if we turn from these organic colloids to the inorganic colloids, which do not need life to make them, we may be on the right track. As far back as November, 1911, Professor Moore began to experiment with solutions known to chemists as the hydroxides of uranium

and iron. These have the curious characters of colloids, but are inorganic, not needing life to make them. The question was whether such inorganic colloids would serve as the means by which sunlight could build up the compounds which are characteristic of life. If they could so serve, then we might believe ourselves nearer to the origin of life upon the earth than science has yet been able to reach.

A First Step from Non-Living to Living Matter. It was formalin or formaldehyde that Professor Moore hoped to observe the formation of under these conditions. Since 1906 we have had proof that formaldehyde is constructed by sunlight in the green plant, thanks to the indispensable presence of its chlorophyll. This is the initial step in the chemical cycle of the living world today; but, as we have seen, it requires the chlorophyll to be there first, and the chlorophyll requires the life to be there first. But if inorganic colloids, such as salts of iron, could enable sunlight to construct formaldehyde, we might believe that we were witnessing the initial step from the inorganic to the living world.

Professor Moore's Experimental Success. For more than a year Professor Moore's experiments failed to reveal any positive result, but in the spring of 1913 he succeeded in discovering formaldehyde, made *in the absence of life*, by the action of sunlight on water and the carbon dioxide of the air, in the presence of inorganic colloids. Exceedingly dilute solutions, either of the iron compound or of the uranium compound, are all that are needed. So long as the sunlight was inadequate, or was cut off by unsuitable glass of the vessels needed for the experiment, no formaldehyde was formed. Control experiments carried out in the dark yielded no formaldehyde whatever. The ultra-violet rays of sunlight were found to be the most effective—that is, the "chemical," "photographic" or "actinic" rays to which our eyes are insensitive, but which are well known to have the greatest chemical power in many other directions.

Similarities in Nature and Experiment. A point of great importance is that, in these experiments, the colloids used *were not themselves changed*. They acted simply after the fashion of ferments, being the means of profoundly important chemical reactions, yet themselves taking no share in those reactions. When formaldehyde is made in Nature in the green plant, the chlorophyll, the organic colloid, without which the sunlight could not act, is similarly itself unchanged.

Professor Moore further found that a mercury lamp would provide the necessary light, and that formaldehyde could be produced by it as readily as by sunlight. In either case the energy of the light is taken up and built into a new compound, formaldehyde, which, as we have already learnt, is itself the starting point for such substances as sugar and starch, upon which the green plant lives—to say nothing of ourselves. Without the intervention of the living cell, in these experiments sunlight has been turned into "organic" carbon compounds which life can obtain energy from and live by. *The process of what we have learnt to call photosynthesis has been reproduced without recourse to chlorophyll.*

Experimental Conclusions. The following, in the author's words, are the conclusions of this remarkable paper, the momentous character of which will be evident to the careful reader.

"Organic matter (aldehyde) has been synthesised from inorganic colloidal uranic and ferric hydroxides in very dilute solution. These colloids act as catalysts (ferments) for light energy, converting it into chemical energy in a reduction process similar to the first stage of synthesis of organic from inorganic substances in the green plant by the agency of chlorophyll.

"Such a synthesis occurring in nature probably forms the first step in the origin of life. For chlorophyll and protoplasm are substances of far too complex chemical constitution to be regarded as the first step in the evolution of the organic from the inorganic.

"Without the presence of organic material, when life was arising in the world, any continuance of life would, however, be impossible.

"The process of evolution of simple organic substances having once begun, as now experimentally demonstrated, substances of more and more complex organic nature would arise from these with additional uptake of energy. Later, organic colloids would be formed, possessing meta-stable properties, and these would begin to show the properties possessed by living matter of balanced equilibrium, and up-and-down energy transformations following variations in environment.

Life Forming Always, Everywhere. "There can be little question that such energy changes as are above described occur at present, and are leading always to fresh evolutions of more complex organic substances, and so towards life; and equally is it true that they must occur on any planet containing the necessary elements for the evolution of inorganic colloids, and exposed to light-energy under suitable conditions of environment."

The Manufacture of the Means of Life. Here, then, is the most recent, most authoritative and best-supported teaching of science on the great question of the "origin of life." One truth always leads to another. Believing that microscopic cells were the simplest possible forms of life, the nineteenth century could get no further with the problem of the origin of life, for all the evidence seemed clear that such cells do not arise except from cells like themselves today. But the discovery that there are simpler forms of life than the amœba, and that there must be simpler forms of living matter than protoplasm, has led students of the chemistry of life much nearer to the real beginning. How to turn sunlight into the stream of life, *without the help of pre-existing life*, that was the question, and Professor Moore has at least taken the great step of proving that sunlight,

acting on not-living material, can produce one of the characteristic foodstuffs of the living plant. Hence he is perfectly entitled to argue, as he does, that life may be taking its origin, on our own planet or any other world, in the present or at any past time, wherever the necessary conditions of light or radiant energy from without, and suitable materials for it to act upon, are found.

Incipient Life Waiting its Chance. This view is consistent with the whole theory of evolution, and makes it unnecessary to call in the aid of a "special creative act" for the origin of life. On the contrary we have the vision of a continuous evolutionary process, as described by Herbert Spencer in his great statement of Universal Evolution, a process which passes onward from the lifeless to the living according to orderly and certain laws. Further, this conception teaches us to look upon life as potential, incipient, waiting its chance, in and behind and through matter everywhere. This is a great philosophic conception, as old as human thought, but distinctly nearer scientific demonstration today than it was even only a year ago.

Dr. Russel Wallace's Theory of Earth-reared Life. Dr. Alfred Russel Wallace devoted the latter part of his life to various social and philosophical problems of high importance, including this problem of the origin of life and its distribution in the Universe. The conclusion which he reached, in his remarkable book "Man's Place in the Universe," was that this earth alone could sustain life, and could thus become the home of intelligence, as we find it in man. Dr. Wallace's views must here and now be rejected, with all deference to the sincerity and intellectual power of his argument.

He was able convincingly to show, as a master in the study of adaptation, that the earth and its life are exquisitely and subtly adapted to one another. Hence he was justly entitled to conclude that life as we know it could not exist—could neither have arisen nor, having arisen, be maintained—upon any planet in the whole Universe unless that planet were an absolute duplicate of our own earth. Dr. Wallace's demonstration of this proposition was complete, and his book will long be remembered and long be worth reading. But the evolutionary theory, in the development of which Dr. Wallace played a distinguished part, asserts that living things have adapted themselves to their environment, that life asserts itself as and how it can.

DR. BENJAMIN MOORE AT WORK IN HIS LABORATORY AT LIVERPOOL UNIVERSITY

The Infinite Variation of Life. The forms or effects of life which are not adapted well enough must die out, and that is what happens in the process of "natural selection," which was independently thought out by Darwin and by Wallace. The forms which life takes, on this theory, depend always upon the circumstances of the environment or surroundings. A form of life which required to breathe an atmosphere of pure oxygen, let us

suppose, could not exist on our earth, because there is no such atmosphere at its disposal; and so with any other case we choose to imagine. The arguments of Wallace that the forms of life we know could arise and survive only upon our earth were irresistible. But he had no right whatever to assume, as he did, that the forms of life we know are the only forms which life could take. On the contrary, the whole theory of organic evolution assumes that life is capable of all but infinite variations according to the varying circumstances in which it may find itself. Only upon the earth, assuredly, could we expect to find terrestrial life; but that is no reason why Martian forms of life should not have evolved upon Mars—forms which would surely die upon our earth, as probably any form of earth-life would perish if suddenly transferred to Mars.

Life in Waiting for Opportunity. According to reason and to philosophy, the deeper and wiser belief is that which Professor Moore has so recently afforded this new and remarkable evidence to support. It is the belief that everywhere throughout the Universe, behind all matter everywhere, lie invisible the possibilities of life, awaiting, so to say, their opportunity. The laws of matter and energy, the laws of chemistry and physics, we have the right to believe, are universal: they apply in the sun or in Sirius as they do upon the earth. The same kinds of elements are found making up all matter. Radiant energy, such as that of the sun, pervades all space—*the Universe is full of light.* From star to star, outwards in all directions, this radiant energy flows. Look upwards upon a clear night, and it flows into our eyes from millions of stars. Of course, its intensity varies in different places; much less intense light falls upon Jupiter, and much less still upon Neptune, than falls upon our earth from the sun.

But this play of radiant energy, more or less, of course, is everywhere, and the matter upon which it falls is everywhere fundamentally the same, and obeys the same laws. We have just learnt how radiant energy can build itself up into chemical compounds *on the way*, at least, towards those which life inhabits; and we have every reason to follow Professor Moore when he argues that similar results may follow anywhere in the Universe, at any time, whenever the necessary combination of conditions is satisfied. How many kinds of conditions will not suffice, and how many kinds of life may not thus be naturally evolved, no man can say.

Only a First Step. While the reader will attach very high and special importance to these new experiments, seeing how immense is their significance, we must beware of supposing that we have gone all, or nearly all, the way when we have taken only the first step. Professor Moore has done no more than that; but this is pre-eminently a case, we may hope, where "it is only the first step that counts." We cannot be too exact or clear in our understanding of the position which science has now reached in regard to this mighty problem, and therefore it is well that we should have before us the words which Professor Moore wrote a few months before he achieved success. Here is the exact quotation of his statement of the problem.

Where the Experiment Stops Short. "If a mental picture be conjured up of a world in which there is as yet no life, but where conditions are suitable for life to appear, it is evident that a spontaneous production of such a thing as even a bacterium or other unicellular organism would by no means solve the problem, the new-born cell would have no organic pabulum, and must perish. The production of anything so complex as chlorophyll at such a stage is unthinkable to anyone acquainted with the subtle continuity of all nature. In such a world inorganic celloids must first develop, and in time one of these must begin to evolve, not a living cell, not anything so complex as a micro-coccus or a bacillus, not even a complex protein, carbohydrate, or fat, but *some quite simple form of organic molecule, holding a higher store of chemical energy than the simple inorganic bodies from which it was formed.* To carry out such a function the inorganic colloid must possess the property of transforming sunlight, or some other form of radiant energy, into chemical energy. Later, such simple organic compounds, by the agency of the same or some other colloid, and with a supply of external energy, would begin to condense and form more complex organic molecules, and finally complexes of inorganic and organic matter would come into existence as crystallo-colloids. In this way, without any hiatus, life would be led up to, and inaugurated."

Hope of Bridging the Abyss. The words we have italicised in this quotation exactly describe the formaldehyde which Professor Moore has since been able to evolve by the action of sunlight on inorganic colloids. But his words will show how far we have still to go, and will correct the impression—which was, unfortunately, aroused by several newspaper reports of his work—that he had "created life" in his laboratory. What he has done we can now learn from his own words, some written before and some written after his experimental success. Remarkable developments may soon be expected from so auspicious a beginning. It reaches surely, though as yet only a very little way, out across that unbridged abyss, between the lifeless and the living, which the theory of Universal Evolution must bridge, yet which utterly defied the best efforts of the century of which that theory is the greatest intellectual achievement.

Meanwhile, science owes something like an apology to the memory of Herbert Spencer, the fearless and independent thinker who never admitted the possibility of a non-natural gap in Universal Evolution, from the lifeless to the living. Men of science used to laugh at him, though Darwin, the greatest of his contemporaries, called him "our great philosopher." The experiments of our own time suggest that he was great indeed when he declined to cut the universe into separate parts, but traced the evolution of life as the fruit of inorganic or cosmic evolution. C. W. SALEEBY

The Race of Nations for Commercial Supremacy
Dangers and Difficulties that Have to be Faced

FUTURE OF THE EXPORT MARKET

As we showed in dealing with the future of the home market (p. 735), the maintenance of British export trade is essential to the national existence. Without enormous exports we should necessarily sink in the scale of nations, because our own natural resources, apart from coal, are so poor that we have to import by far the greater part of the raw and crude materials of our work. A self-contained United Kingdom is, of course, a possibility, but self-containment could only be purchased at the price of a very low scale of living. With it the greater part of our industries would disappear, and no small part of our population, deprived of imports upon which to exercise their skill, would be driven to emigration. That done, a greatly reduced population could exist at a very much lower standard of life by agricultural work and subsidiary industries.

In considering the future of the British export trade, therefore, we come to the review of a subject of vital importance to our people. It is a matter in which every citizen of the country is interested, no matter how employed. An occupation may not appear to depend upon, or even to be connected with, export trade, but the circumstances of our national economy, as explained in the article dealing with the home market, forbid anyone to believe that his work is really independent of external trade.

A builders' labourer, for example, may conceive himself as working in a purely domestic industry, but the fact of the matter is that his labour would probably not be wanted if wealth derived from external commerce had not created population and led to a consequent demand for houses for that population. A journalist, again, may seem to be wholly outside the influence of external commerce; as a matter of fact, his employment depends upon conditions of wealth and population in a country which has risen to its present position largely through an intelligently directed export trade. If we are to form a proper idea as to the possible future of British export trade, it is necessary to understand the past. A table on the next page gives a broad review of the commerce of the United Kingdom from the beginning of the nineteenth century to the present day.

It should be borne in mind in considering the table that prices have varied considerably during the long period dealt with. Prices fell generally, with some intervals of re-action, right through the period down to about 1896, when they began to rise again, the prices of the present time being very much at a level with those of the 'eighties.

It will be seen that, taking into account both the rise in values and the fall in prices, the volume of British exports has risen enormously. Especially let us note how exports rose in the middle of the nineteenth century. Between 1850 and 1870 the value of British exports rose from £71,000,000 to £199,000,000, an increase of £128,000,000, or 180 per cent. Then, it will be perceived, there was a slackening in the rate of advance, although the advance continued.

That slackening is not difficult to understand. Down to about 1870—we speak of the modern industrial era which began in the latter part of the eighteenth century—Britain had things all her own way in the world of industry and commerce. That arose from the fact that British inventors, by unlocking the secret of coal power, gave an extraordinary and peculiar advantage to their country. Britain was for a considerable period in a position which can only be described as unique. She was founding large-scale manufactures, which had never existed in the world before, upon the basis of her coal mines. She was one of the few countries in the world which possessed a great coal supply, and the others who were equally fortunate in great fuel resources were not in a position to use them to any great effect. Under such circumstances it is not surprising that our British commerce continued to increase by leaps and bounds.

UNITED KINGDOM'S EXTERNAL TRADE

NOTE.—This table shows the value of imports and exports as declared at the Customs. Imports are valued c.i.f. (i.e., inclusive of freight and insurance charges). Exports are included f.o.b. (free on board) at British ports.

Year	Imports	Exports of British Goods	Exports of Imported Goods
1805	Value not recorded	38	Value not recorded
1810	" "	48	" "
1820	" "	36	" "
1830	" "	38	" "
1840	" "	51	" "
1850	" "	71	" "
1860	210	136	29
1870	303	199	44
1880	411	223	63
1890	421	263	65
1900	523	291*	63
1910	678	430	104
1912	745	487	112

* From 1900 onward the figures include value of exports of new ships not previously recorded.

Germany Under Industrial Discord. Let us consider the position occupied by Germany in those early days of modern industry. In the early part of the nineteenth century, when the United Kingdom possessed internal unity and internal peace secured by her Navy, the German Empire consisted of about two hundred different kingdoms, duchies and states of various kinds, which not only waged commercial warfare upon each other by means of protective duties, but had different systems of weights and measures and of coinage. Germany, in short, was a "geographical expression," consisting of a large number of states which did their best to injure each other's trade, and succeeded very well in the task. It was not until 1833 that a German Customs Union was formed, but still the various states retained their different coinages and weights and measures. Large parts of Germany remained outside the Customs Union for many years; Hamburg, Bremen, and Lübeck, the great ports which mean so much to Germany, did not join the German Customs Union until 1866, 1888, and 1889 respectively. Thus Hamburg did not become one with Germany for trade purposes until four years before the Franco-German War.

Germany Under Industrial Unity. In 1870 German unity was won, and the various German states recognised in the King of Prussia a German Cæsar. Then, and then only, was it possible for Germany to take up in peace the work of industrial and commercial development which centuries before she had shown herself so capable of. The dreadful Thirty Years' War of 1618-48 prostrated the German peoples, robbed what is now Germany of one-half of its population, and reduced some of its districts to deserts. Between the end of the Thirty Years' War and the Franco-German War, the study of German history will show how little chance she had to recuperate. Before 1618 the great German cities were world-centres of trade, but not until modern times had they the chance to exhibit their old capacities in the arena of commerce. When at last Germany had opportunity to develop her great power resources, it is not surprising that she made rapid progress, but it was not until the 'eighties that the British people awoke to the fact that a great commercial competitor had arisen in Europe. As recently as 1875 Germany produced only 48,000,000 tons of coal (including lignite) in a year. In the course of the next ten years the output was nearly doubled.

Growth of Population in the United States. When we turn to the third great industrial nation, the United States of America, we are reminded that in the early days of the modern industrial period America, like Germany, was not in a position to develop her mighty resources for lack of population. In 1800, when the small area of the United Kingdom contained nearly 16,000,000 people, *the United States contained only* 5,000,000 *people*. In 1820, when the United Kingdom had 21,000,000 people, the United States contained less than 10,000,000 people. Even in 1850, when the United Kingdom contained 27,000,000 people, the United States had only 23,000,000. In the next forty years, however, population flocked to the United States, the country gaining forty millions of people in forty years, so that in 1890 the population was nearly 63,000,000. In 1914, after only 24 more years, it is about 97,000,000.

Parallel Expansion of People and Resources. It needed only population to prove the extraordinary value of American natural resources, which are greater than those of Britain and Germany put together. Her coal is magnificent, but it is rivalled by her oil, fertility, forests, copper, lead, and so on. Even in the period of British most rapid development, there were wise men among us who foresaw that America must come to produce much more than ourselves in the time to come, and their prophecies have been faithfully fulfilled.

We cannot take a better measure of the nations in point of productive power than by ascertaining their coal productions. The following table refers to both coal and lignite.

THE WORLD'S COAL POWER

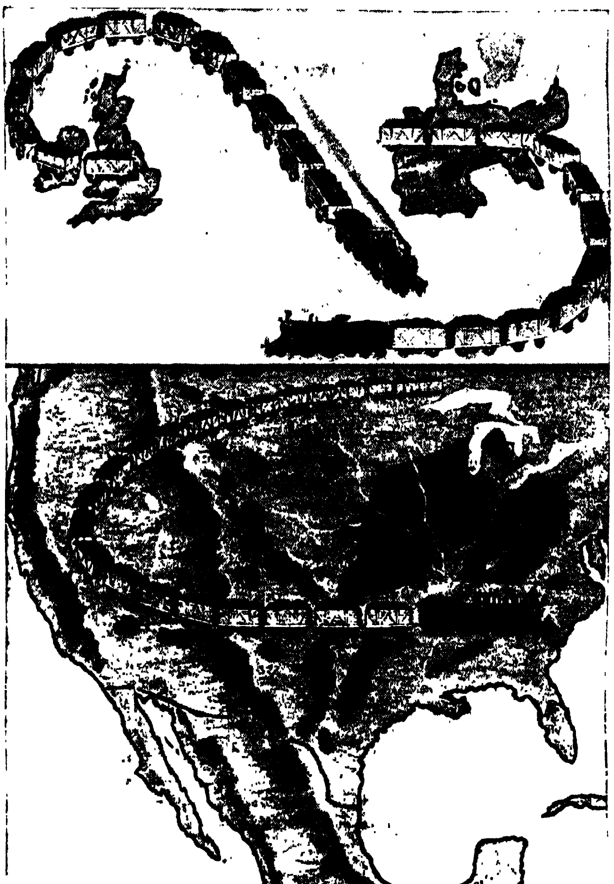
Shown in Millions of Tons Avoirdupois

COUNTRY.	1875	1885	1895	1905	1911
United Kingdom	133·3	159·4	189·7	236·1	271·9
United States	46·7	99·1	172·4	350·8	443·0
German Empire ..	47·8	72·4	102·3	171·1	230·8
United Kingdom, United States, and Germany together	227·8	330·9	464·4	758·0	945·7
British Possessions ..	2·9	6·6	12·9	28·8	42·3
France	16·7	19·2	27·5	35·4	38·7
Belgium	14·8	17·2	20·1	21·5	22·7
Austria-Hungary ..	12·9	20·0	32·1	41·8	47·3
Russia	1·7	4·2	8·8	18·4	22·8
Italy	0·1	0·2	0·3	0·4	0·5
Spain	0·7	0·9	1·7	3·4	4·0
Sweden	0·1.	0·2	0·2	0·3	0·3
Japan	—	1·3	4·8	11·8	15·8
The World	277·7	400·7	572·8	919·8	1140·1
United Kingdom output expressed as percentage of world output	48·0	39·7	33·1	25·6	23·8

The Race for Productivity. We see that in 1875, when British industry was absolutely supreme in the world, British coal mines actually produced as nearly as possible one-half of all the coal produced in all the world. Germany and America together, although with much greater coal resources than we had, were producing between them only 94,000,000 tons of coal, against the 133,000,000 tons we produced.

Now let us observe how rapid a change occurred. After the passage of only ten more years, we find that in 1885 the American and German coal outputs were together rather more than our own, being 171,000,000 tons against our 159,000,000 tons. We also see that in 1885, although our coal output had increased, it had relatively declined, having fallen to about 40 per cent. of the world's output.

Another ten years passed, and again the position had greatly changed. We see that the British output had fallen to about one-third of the entire world's output, while the American output had become almost as great as our own, and the German output had considerably increased. Ten years later, in 1905, America had taken a tremendous lead of us, while the German output of coal and lignite had advanced to 171,000,000 tons against our 236,000,000 tons. The British output had then fallen to just a trifle more than one-fourth of the entire world's output.



COAL OUTPUT OF THE THREE GREATEST NATIONS
In this diagram the coal districts are shown dark. Each truck repres 20 million tons of the annual output.

It is a very notable fact that three countries, the United Kingdom, the German Empire, and the United States of America, produce 9 out of every 11 tons—or just over 80 per cent.—of the coal of the world.

Advances Real and Relative. If we consider the British figures alone, we see what a wonderful advance in coal output—in industrial power—has occurred in the United Kingdom. On the other hand, if we consider the British figures relatively to the world's figures we see that, although the United Kingdom has actually advanced, it has relatively declined. And that is exactly what was bound to happen in the nature of the case. The early rapid advance, as we have seen, was an almost undisputed advance. In later years, however, we had to contend with the fact that there were other Richmonds in the field, armed as well as, or better than, ourselves.

Test of Coal Power. We may also observe what an extraordinary advantage is possessed by Britain, the United States, and Germany together over the rest of the world in point of power resources. It is a case of these three first and the rest nowhere. France, Belgium, Austria, and Russia put together do not produce nearly as much coal as Germany. Some countries, we see, have literally no chance. Italy, Spain, and Sweden, for example, have so little coal that it is negligible, and it will be noticed that some other countries, for example, Denmark, do not appear in the table at all, being destitute of coal. Such countries have necessarily to remain agricultural countries, and therefore poor countries in comparison with better endowed nations.

The Levelling-down Effect of Coal-getting. There is a good deal of uncertainty as to the quantity of coal actually possessed by different nations at workable depths. There are considerable coal areas in Russia, Australia, Canada, India, and especially China. China, indeed, is probably one of the greatest coal countries of the world, and in the time to come she may become a great industrial power—if coal remains the chief source of industrial power. As to the other countries named, while they have great coal areas, they do not appear to have great quantities of coal which can be *cheaply worked*, which is the chief asset under present conditions

It should be observed, however, that as those countries which have the most available coal cream their resources, they equalise their advantages as compared with the countries which have deep and dear coal.

The Advent of Oil. Some of the coal nations also possess fine mineral oil resources, but the amount of this naturally distilled product in the world does not appear to be great enough to make it a serious competitor of coal as a source of power, although it is apparently destined to make a great mark in connection with shipping.

Indeed, if oil comes to be used universally in ships, it will be a great misfortune for the United Kingdom. This ought to be thoroughly understood. While the world's ships are run with coal, there is great need for coaling stations throughout the world, and the United Kingdom therefore exports large quantities of coal.

Effect of Coal Cargoes on Trade. These coal exports play a profound part in the prosperity of British shipping because they furnish good outward cargoes. Their value is great for the following reason. Our imports, which chiefly consist of food and raw materials, are heavy and bulky, and therefore form big cargoes. Our exports, on the other hand, chiefly consist of manufactured articles which, value for value, are small in bulk as compared with food and materials. Thus it follows that our exports of manufactures, although great in value, are comparatively small in bulk. We have, therefore, a picture of many ships being needed to bring in our imports and few ships being needed to take out our exports, and if ships coming in with cargoes have to go out in ballast, shipping is unprofitable. Clearly it is fortunate for British shipping that coal exports exist, because they form a bulky cargo and balance our bulky imports.

The Rivalry of Coal and Oil. If oil supplants coal for the world's ships, our coal exports will not be required, and consequently our shipping will be injured by the loss of most valuable outward freights.

That is a pertinent reminder of how scientific progress unequally affects the nations of the world. The man who developed the modern steam engine made a gift to all the world, but especially a gift to the coal countries. The men who are developing the modern oil engine are hitting us in two ways: (1) Because we have no oil, and (2) Because of the peculiar value to us of coal exports for shipping purposes.

The Competition of Water Power. In recent years there has been a considerable development in some parts of the world of the use of water power, and this has made a considerable change in France, Italy, Switzerland, and other countries which have the good fortune to possess water power. A specialised engineering has arisen in this connection. The use of water power is even more local than the use of coal, and some nations are almost destitute of it. As far as it exists in the world it is a point against the competitive power of the United Kingdom, as we are not well off in this respect. It was estimated for the Royal Commission on Coal which sat in 1901 that if all the British water power was utilised it would be only equivalent to the use of 1,200,000 tons of coal per annum. Many other countries are more fortunate, but it does not appear that water power is yet a serious competitor of coal.

How Coal Power Favours England. One paramount consideration stands out with regard to any new sources of power which may in time to come supplant coal. It is that the new source of power is unlikely to be one which will confer such *peculiar* advantages upon the United Kingdom as coal now confers. While coal is the arbiter of economic strength, it is well for the nation which has it in such abundance and cheapness as we have it. If and when coal is supplanted, our extraordinary advantage in this respect will disappear.

Here, however, we get into the region of speculation. We cannot control the development of science; all we can do is to utilise what resources we have in the best possible way, and to neglect no possible means of conserving what is now and what is for long likely to be the chief source of power in the world. If coal is supplanted we cannot blame ourselves, but while coal means so much to us we ought to do everything that we possibly can to use it to advantage.

It is impossible to consider the future of the British export market without having regard to these vitally important considerations. In view of the unique character of our commerce, there is a strong case for the establishment of a National Power Commission, charged with the survey and conservation of our power resources. As things are, the most important British material asset is entirely neglected by the powers of Government, save in respect of certain laws made for the regulation of mining work.

The Power Race in the Twentieth Century. If reference is again made to the table on page 866, exhibiting the progress of British exports, it will be seen that in recent years there has been a further advance on a large scale. Since 1900 the increase has been remarkable, and it is worth special attention. It is a most encouraging increase, because it has been made, unlike that of the 'sixties, in a world in which, as we have seen, other countries have greatly developed. Let us consider this a little further. Here is the advance made in exports by the leading nations in the twentieth century, for the latest year for which the figures are available.

EXPORTS OF THE LEADING COMMERCIAL NATIONS IN 1900 AND 1912 COMPARED

COUNTRY	1900	1912	Increase in 12 Years.
	£	£	£
United Kingdom	291,000,000	487,000,000	196,000,000
German Empire ..	227,000,000	437,000,000	210,000,000
United States ..	286,000,000	452,000,000	166,000,000
France	164,000,000	265,000,000	101,000,000
Belgium	77,000,000	156,000,000	79,000,000
Austria-Hungary	81,000,000	111,000,000	30,000,000
Italy	54,000,000	96,000,000	42,000,000
Russia	76,000,000	151,000,000	75,000,000
Japan	22,000,000	54,000,000	32,000,000

Years ended on December 31st. The United States' figures are for years ending on Jan 30th.

These records show that there has been a wonderful expansion of trade by all countries in these later years. It is not the case, as in the early days of British commerce, of one nation being first and the rest nowhere. A moment's consideration will show that that is so much the better for us. We see that, whereas in the old days our expansion was secured while other nations were incapable of competing, our trade expansion of the twentieth century has been can be little doubt that the present production of material commodities in the world as a whole, and of trade based upon that production, will in the near future reach dimensions very much greater than those exhibited in the world statistics of today. Mankind is obtaining a surer grasp upon the world and its resources. Transactions are taking place upon a larger scale than ever before. We learn to talk in millions, where not long ago we thought it great

THE EFFECT OF THE PANAMA CANAL ON THE TRADE ROUTES OF AMERICA, SHOWING HOW IT SHORTENS THE DISTANCE BETWEEN NEW YORK AND THE FAR EAST

secured in spite of the existence of several very strong competitors.

Thus we see commerce not as a thing of narrow limitations, and not as a matter in which the gain of one nation means necessarily the loss of another. We get a view of it rather as a thing capable of indefinite expansion, and it is urged here that that is a view which is as true as it is hopeful for the future of British exports. There to talk in thousands. Capital is employed on an unprecedented scale, and a new race of organising men has sprung up, who are learning to survey the entire world in connection with their operations. Industries are becoming world-wide in their scope. Captains of industry are beginning to employ science at every step in their operations. All this must lead to an enlargement of the scale of trade.

The Trade Calls of a Higher Life. In addition, there is the hopeful fact that throughout the world the masses of mankind are beginning seriously to seek for a higher standard of life, which means the employment of an enormously greater volume of material commodities. If we imagine only a tithe of the desires of men translated into an actual call for goods, we see what great room there is for the expansion of trade.

Effort Must Replace Privilege. Therefore, in spite of the progress of other nations, the United Kingdom may legitimately hope not only to maintain but to increase its business, given enterprise and efficiency on the part of its people. Without these qualities, of course, nothing can avail, for the world as a whole is growing ever more efficient, and the days are disappearing when rough work and rule-of-thumb methods can avail. We have spoken of natural resources, but we do well to remember that the greatest resource of all is the people themselves. If the United Kingdom stood alone in the world, it would be obviously our duty to make the most of our human material; but, as we have seen, we are no longer in the position of peculiar and solitary advantage which we occupied fifty years ago. In point of natural resources, some other nations are better advantaged than we are. It is, therefore, doubly incumbent upon us to keep abreast of a strenuous age, in which it is ever increasingly true that the battle goes to the strong.

The Panama Canal as a Handicap. We shall have to reckon from time to time with changes of such a character as are illustrated by the Suez and Panama Canals. The cutting of the Suez Canal in 1869 gave to Europe, and particularly to ourselves, the chief maritime nation, very great advantages. The completion of the Panama Canal in 1915 will set up new currents of trade, and alter the world's trade routes to our disadvantage by giving a greater relative gain to America. As we already have the advantage of the Suez Canal route, giving us easy access to the Far East, the new Panama route does not matter much to us. The American position is very different. The voyage from New York to Japan via the new canal means a saving of 3700 miles. The voyage from New York to Sydney, which is now eastward round the Cape of Good Hope, 14,000 miles, will in future be westward, and shortened by 4000 miles. The cutting of the Panama Canal gives to American Atlantic ports a great gain in trade with the Orient and with Australasia, in which the United Kingdom does not share, although, of course, it is shared by our possessions in America.

Trade Gains in South America. It will also be seen that the trade of the United States with the important and growing markets of South America will very greatly gain. The voyage from New York to Pacific Coast ports south of Panama will be shortened by from 1000 to over 8000 miles. Similarly, Pacific ports of the United States will gain in relation to Atlantic South American ports.

Take another illustration, that of the relations of Liverpool and New York with San Francisco. Before the opening of the Panama Canal, the voyage in each case is round Cape Horn, so that for practical purposes Liverpool is almost as near to San Francisco as is New York. As soon as Panama is open New York is brought nearly 3000 miles nearer San Francisco, with consequent relative gain to New York and relative loss to Liverpool.

American Gain by Tariff Freedom. In this connection we have to consider the relaxation of the American tariff in 1913, which will make it easier for the United States to trade with other countries, and to build up big exports. There is good reason to believe that, between the opening of the Panama Canal and the establishment of a wiser tariff policy, the United States will make great strides in commerce in the very near future. As we have indicated, that advance need not necessarily be at our expense; but in view of the fact that ours is the greatest commerce in the world, we obviously stand to lose most if our additional efforts are not commensurate with the new disadvantages imposed upon us by forces beyond our control.

Surveying the world as a whole, we see what enormous room there is for trade expansion. In dealing with the future of the British home market, we made it plain that in one of the richest countries of the world there is as yet but a very small demand for miscellaneous goods by the mass of the people. If that is true of the United Kingdom, how much more is it true of the other countries of Europe? And if European countries have a great and as yet unsatisfied need for goods, what are the opportunities offered by the hundreds of millions of Asia and Africa and America?

The great problem of the future, it is clear, is the problem of translating into actual and effective demand the growing need of the world's masses for goods. It is a problem which presents considerable difficulties, but it will undoubedly be solved, and solved greatly to the profit of the nation which has the energy and enterprise not only to create the demand in its own area, but to secure the custom of this enormous foreign market.

An Ever-widening World Market. It is difficult to realise, but it is true, that by far the greater part of the people of the world as yet make no call worth mentioning upon the products of modern industry. The time will surely come, however, when that call will arise. Those who are responsible for British export trade, therefore, may look with confidence to an ever-widening world-market. It is true on the one hand that Britain is no longer the only great workshop of the world, and that competition is ever becoming fiercer. On the other hand, as we have shown clearly by reference to what has actually happened in the twentieth century, there is still more than room for us in export markets, and opportunities in foreign commerce were never greater than they are at the present day. L. G. CHIOZZA MONEY

Fluid Pressure. The Laws of Fluids. The Barometer. The Syphon. The Pump. The Hydraulic Press. Fluids in Motion.

THE PHYSICS OF FLUIDS

In the language of physics, it must be remembered that both liquids and gases, because they flow, are included under the term of fluids. The most important instance of fluid-pressure—the most important fact about fluids—is the atmospheric pressure. Everyone has heard the phrase, "nature abhors a vacuum," but the phrase is far too metaphorical to lead to the truth, and it was not until the time of Galileo that the explanation of the fact was discovered.

Fluid Pressure. The credit for the discovery lies with his famous pupil Torricelli. It was found that water would rise about 30 ft. in a pump, but no pump could draw water from a depth of 50 ft. Now, mercury is many times heavier than water, and Torricelli supposed that in all probability mercury would rise in a similar way to water, but to a much less height in proportion to its greater weight; and he was right. If we take a long glass tube closed at one end, fill it with mercury, and then turn it upside down in a vessel containing mercury, we find that all the mercury does not run out of the tube; on the contrary, the mercury sinks in the tube only to such an extent that there remains in the tube a column of mercury which is at a height of about thirty inches above the level of the mercury in the vessel.

This is the famous Torricellian experiment, which demonstrates the fact that the atmosphere has a pressure; for the only possible difference between the long column of mercury in the tube and the mercury in the vessel is that the one is exposed to the atmosphere and the other is not. The column of mercury in the tube is supported by the pressure of the atmosphere on the mercury outside it. The space in the tube above the level of the mercury is as nearly a perfect vacuum as can be obtained—that is to say, it contains scarcely any air at all. It is known as a *Torricellian vacuum.* Only a few years after the first experiment of Torricelli, Perier, the brother-in-law of the celebrated writer Blaise Pascal, made the experiment of carrying one of Torricelli's tubes to the top of Puy de Dome, and found that at the top the level of the mercury was considerably lower. He further found that as he came down the level of the mercury rose, and thus it was plainly shown that the atmosphere possesses a pressure and that this pressure lessens as we ascend in it.

The Barometer. (Greek *baros*, weight, and *metron*, measure.) The reader will have already seen that the Torricellian tube is a barometer—that is to say, an instrument for measuring the pressure of the atmosphere. That, of course, is all that a barometer does; it tells us nothing about the weather directly, but is of use in this connection merely because the state of the atmospheric pressure at any given time is by far the most important factor in the determination of the weather.

Torricelli's tube, however, is a very inconvenient barometer, and it is more convenient to have a U-shaped tube, constituting what is called a syphon barometer. This, again, may be easily modified so as to give us what we call a weather-glass. If we place an iron ball so as to float upon the mercury at the open end of the tube, and attach a string to the ball, and a weight to the end of the string by way of balancing the ball, we can conveniently pass the string over a wheel, and to the wheel we can attach a pointer; this pointer can then be made to indicate such legends as "set fair" or "changeable," printed on a circular card. The principle of Torricelli may be employed in a number of different forms, such as the Kew barometer, the marine barometer, and others which do not concern us here. But we may also measure the fluid pressure of the atmosphere by means of another instrument which is much less fragile, because it contains no mercury or glass.

Aneroid Barometer. The aneroid barometer—literally meaning a barometer that contains no liquid—is simply a round, flat metal box emptied of air, and having a spring attached to it. The varying pressure of the atmosphere causes the top and the bottom of the box to approximate to one another in varying degrees, which are recorded by the spring, and this spring moves a pointer by means of a lever. The aneroid is quite a convenient little instrument, but it has, of course, comparatively small pretensions to accuracy.

When accuracy is wanted it is necessary to correct the readings of even the mercury barometer in various ways; of these the most important is the correction for temperature, so that a first-class barometer always has a thermometer with it. It is hardly necessary to say that the mercury expands as the temperature rises, and unless this were allowed for, we should get the impression that the atmospheric pressure was higher than was actually the case.

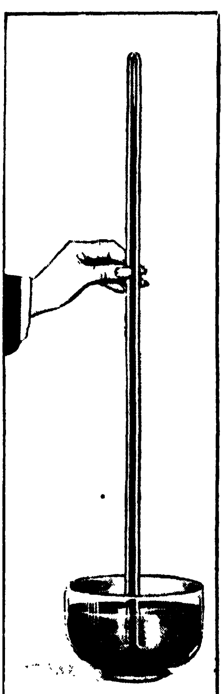
The most important points in the construction of a barometer are to make certain that the mercury is pure and absolutely clean, and to boil it. By this last precaution we expel all air and moisture which would otherwise tend to accumulate in the Torricellian vacuum, and would thus make the reading unduly low.

The English "Standard Atmosphere." The atmospheric pressure is a direct result of the earth's gravitation, and is simply an expression of the fact that the air has weight, and thus exercises a pressure on anything that may be immersed in it. The English "Standard

Atmosphere"—the word atmosphere or sometimes "atmo," is now used in this fashion—is taken as equivalent to the weight of a column of pure mercury 30 in. high, or about 14·7 lb. to the square inch. This is taken at Greenwich; the French take their standard at Paris. Owing to the fact that the earth is not a true sphere, and thus the various points on the surface of the earth are not all at the same distance from the earth's centre, it is necessary, when exactness is required, to state the latitude where the reading of the barometer has been taken.

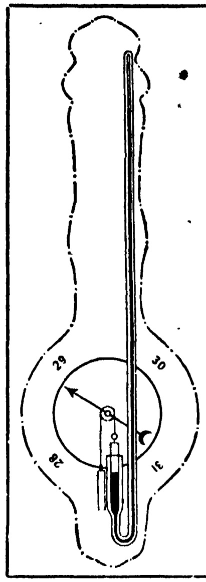
Effects of Atmospheric Pressure. Every square inch of our bodies is thus constantly exposed to a pressure of more than 14½ lb., though we are entirely unaware of it, and feel no discomfort. This is essentially due to the fact that the pressure is the same in all directions. It weighs down upon our heads, but it also supports us on all sides. This fact, that *the pressure of a fluid is the same in all directions,* is not only of cardinal practical importance to all, but is also of great interest to the student of physics. A very simple experiment will demonstrate the fact of atmospheric pressure upon ourselves.

There is an operation known as "dry cupping," which consists in removing part of the air from a test tube or from a tumbler, as, for instance, by burning something in it, and then suddenly clapping it down upon a portion of the skin. In a very short time, as the hot air inside the vessel cools and contracts, and thus causes a lowering of the atmospheric pressure upon that area of the skin as compared with the area that is not covered by the vessel, the covered part begins to swell and rise up into the vessel; this is simply due to the fact that the fluids under the skin are forced by the relatively high pressure exercised upon all the other parts of the body toward the area which has been relieved of part of its atmospheric pressure.



TORRICELLI'S FAMOUS EXPERIMENT

Atmospheric Pressure and Breathing. The atmospheric pressure is also of cardinal importance to us in that it is a necessary condition of ability to breathe. Our lungs have no power of deliberately helping themselves to the air that we need. The requisite air passes from the atmosphere into our blood mainly owing to the fact that the gaseous pressure in our blood—the atmospheric pressure, if you like—is much lower than the gaseous or atmospheric pressure outside it. But, as readers of the course on CHEMISTRY have already learned, the atmosphere consists of a number of gases, and each of these exercises its own *partial pressure* in proportion to the quantity of it that is contained in the atmosphere. Thus, while the partial pressure of the oxygen in the atmosphere is higher than that of the oxygen in our blood, and so causes the oxygen in the air to pass into the blood, the partial pressure of the carbonic acid in the atmosphere, on the other hand, is less than that of the carbonic acid in the blood, and thus the carbonic acid passes from the blood outward to the atmosphere.



MERCURIAL BAROMETER

The Syphon. If we take a U-shaped tube and fill it with water, and then immerse one end of it in a vessel of water, having the other end of it below the level of the water in the vessel, the water will be drawn from the vessel and runs out of the lower end. This simple apparatus is called the *syphon.* The explanation of this action is very simple. The water in the second half of the tube, which is turned downward, naturally tends to run out; but if the water which is at the bend of the tube did not follow there would be a vacuum formed there, and so the atmospheric pressure forces the water in the vessel up the first part of the tube. If, however, the height of the bend were greater than the distance to which the atmospheric pressure can force a column of water, the syphon would not work. That distance, as we saw at the beginning of this chapter, is about 30 ft. This can be proved if, instead of water, we employ mercury in the syphon, and then put it under an air pump. When the air is pumped out and the pressure thus reduced, the mercury ceases to flow through the syphon.

The student of practical chemistry is familiar with a little glass tube, sometimes graduated, which is called a *pipette.* The straw through which one sucks lemonade is really a pipette. When by sucking one end of the tube we remove the atmospheric pressure upon that end, and allow it to act exclusively upon the lower end, it forces the liquid up into the tube. If, then, we put a finger upon the top of the tube or close the top of the straw with the tongue, we are able to hold the liquid in the tube, just as the mercury is held in a barometer. The principle of the little syringe with which we prepare to fill a fountain pen, or of the superior syringe which has a piston, is exactly the same. Remember that the atmospheric pressure has a limit, or, as someone has remarked, by way of ridiculing

the old-fashioned way of talking, "there is a limit to nature's abhorrence of a vacuum." We could not draw up forty feet of water in a syringe.

The Pump. The pump is really a special kind of syringe. As far as its principle is concerned, it is nothing more. We require only some mechanical arrangement so that the water which is raised by the atmospheric pressure, when the piston ascends, shall be discharged at the point required when the piston descends. For this purpose we must have a couple of valves both opening upward, one in the piston, and the other at the bottom of the cylinder which contains the water; and thus when the piston goes down, the water passes through the valve in the piston and escapes by the spout. The force pump approximates more closely to the syringe, for in this case the plunger is solid and the only difference between the two is that, whereas the fluid escapes from the syringe by the same opening as that by which it entered, the force pump has a valve at the bottom of the cylinder opening upward and an escape pipe at the same level.

An interesting instance of the combination of the two methods is furnished by the breathing arrangement of the frog, which consists of a combination of a suction pump and a force pump. The first part of the act of breathing consists in sucking air into the mouth, for which purpose the floor of the mouth drops, as everyone who has observed a frog must have noticed, and thereafter the floor of the mouth is raised and the air is forced into the animal's lungs.

The Laws of Fluids. In discussing the physics of fluids we first of all took up the laws of fluid-pressure by way of an introduction to the subject, as they yield us many interesting facts of practical moment. But now we must go more into the details of the laws which govern the behaviour of fluids, taking first of all the laws of fluids at rest. The technical name for this branch of physics is Hydrostatics; the first part of this word is derived from *hudor*, the Greek word for water. The following are the three great laws of hydrostatics.

(1) Fluid-pressure is always exerted at right angles to any surface which is exposed to it.

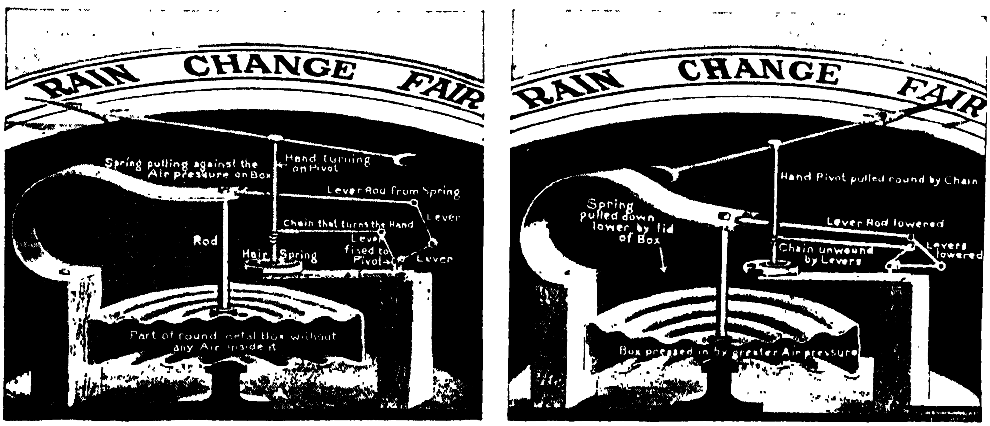
(2) At any point in a motionless fluid the fluid-pressure acts with the same intensity in every direction.

(3) The weight of the fluid being neglected, the fluid-pressure is the same at all points in a fluid mass.

The First Law of Hydrostatics. The first of these laws depends really upon our definition of a perfect fluid. By a perfect fluid we mean one which is perfectly mobile—that is to say, one which is incapable of exercising any oblique pressure upon a surface. Such oblique pressure would be due to the action of friction, and if the fluid be perfectly mobile there can be no friction to act.

Another way of putting this is that a perfect fluid offers no resistance to *shearing stress.* It must be remembered, however, that we cannot experiment with perfect fluids in practice. The fluids we know are not perfect in this sense; they have a certain amount of viscosity—or "oiliness," to use a popular expression—and thus offer a considerable resistance to objects passing through them—a resistance which is more than the result of fluid-pressure as such, but partakes of the nature of friction. The resistance of the air has already been spoken of in dealing with the first law of motion; such resistance is not the result of fluid-pressure at all, but of the fact that the air is not a perfect fluid in the sense we have defined. Still less is water a perfect fluid, though the amount of resistance which it offers to the surfaces of a knife passed through it edge foremost is certainly very slight; but if we are to reach the true laws of fluids we must exclude the action of friction, and so we must conceive of a perfect fluid which offers no resistance to any body, save the resistance which is exerted strictly at right angles to the surface of that body, and which is a result, not of its physical condition, but of fluid-pressure.

The Second Law of Hydrostatics. The law of the equality of fluid-pressure in all directions was discovered by the French

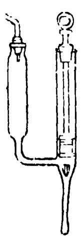


THE PRINCIPLE OF THE WORKING OF THE ANEROID BAROMETER

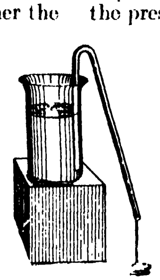
philosopher Blaise Pascal, and is sometimes known as Pascal's principle. It may be reached in two ways—a very conclusive proof of its truth. It may be reached by purely mathematical means which are able to demonstrate that, given the definition of a perfect fluid, the pressure at any point within it must be the same in all directions. But it can also be demonstrated by means of experiment. In the language of logic, we say that the first mode of proof is *a priori* or deductive, whilst the second is *a posteriori* or inductive. We can be absolutely content with our proof of any statement in natural science only when we find that both these methods agree in demonstrating it.

Perhaps the simplest of the many experiments which may be made in order to prove the truth of Pascal's principle is that of corking an empty bottle and weighting it so that it sinks into deep water; it will then be found that the fluid-pressure forces the cork into the bottle and that this occurs in exactly the same way whether the bottle be upright or turned upside down or at whatever angle it be placed.

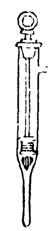
Plainly, this law implies that a fluid exerts an upward pressure as well as a downward one, but it is as much a mistake to think that a fluid has a definite tendency to force things upward as to force them downward. Its pressure is absolutely impartial; this is the cardinal difference between fluid-pressure and the pressure exerted by one solid body on another. This last is exerted in one definite direction only.



FORCE PUMP



PRINCIPLE OF SYPHON



LIFT PUMP

The Hydrostatic Paradox. Now, it follows from the above laws that a very small amount of fluid can be made to support an indefinitely great weight in virtue of the fact that the pressure exerted by the small amount of water can give rise to a great force if it be applied to a wide surface. The pressure exerted by a small amount of water communicating with a reservoir of water is transmitted through it, and is felt and is exerted at every point on the surface of that reservoir. This may be technically phrased thus: if we fill with fluid a closed vessel with plane surfaces—plane meaning flat, of course—and then exert a small amount of force on a small surface of the liquid—say, a square inch—an equal force is exerted on every square inch of the flat surfaces in question, and thus the force is multiplied.

Hence the force exerted by a small amount of water may be able to support a weight indefinitely great. The term *paradox* has been applied to this fact because it seems at first sight impossible that power can thus be multiplied. The truth is that power is not multiplied. No mechanical or other arrangement can multiply or destroy power. What some arrangements can and do constantly multiply is not power or energy, but *force*—a word which is technically used in physics to mean one thing and one only—namely, the ability to do work. Thus the hydrostatic paradox so called is really no more a paradox than the action of a lever, a pulley, or other mechanical arrangement for multiplying force.

The Hydraulic Press. This is often called the Bramah Press, after the man who effected an important improvement in it. It consists essentially of a strong piston working up and down in a strong cylinder. Into the cylinder there leads an inlet from an ordinary force pump; the piston of this force pump is quite small and can easily be worked by a man, but the force he exerts is greatly multiplied in proportion to the ratio between the size of the piston which he is working and that of the large piston of the Bramah Press. The work done on the pump by the man is precisely equal to the work done by the press; there is no multiplication of power.

In order that there should be a real multiplication of power—such as we have said is impossible—the speed of the large piston of the press would have to be the same as the speed of the small piston of the force pump which the man is working. There would then indeed be a creation of power, but this is not so. The piston speed of the pump has to the piston speed of the press exactly the ratio that the area of the press has to the area of the pump. In other words, suppose the piston of the press to be 20 times as large in area as the piston of the pump, it will then move at only one-twentieth of the speed. The mechanical advantage of the machine is that speed is not what is wanted in the press; the speed which in the pump is the direct result of the man's work is translated into force in the press.

The Two Kinds of Fluids. So far we have been able to speak of fluids in general without distinguishing between them, and we have been able to state laws which are true of all fluids. But the reader may have already been somewhat astonished at the inclusion under one term of two things so very different as water and air, and it is now time to distinguish between the properties of two fluids so very different as water and air. The two kinds of fluids are liquids and gases. So far as the laws of hydrostatics are concerned, there is no distinction between them.

Compressibility of Fluids. It used to be stated that the essential difference between a liquid and a gas is that the first is incompressible, while the second is compressible. A gas can be squeezed into a small compass, and when the pressure is relaxed it expands again. It is readily compressible. But if we put some water into a syringe and attempt to squeeze it into a smaller space we find that it is apparently incompressible. There is thus a very great distinction. It is now a long time since the incompressibility of liquids was demonstrated. Bacon, for instance, filled a leaden shell with water, and then hammered and squeezed it in the hope that he would be able to compress the water,

but instead it oozed through the lead. Similar experiments were made long ago in Florence, globes of silver and of thickly gilded silver being employed, but always the water oozed through rather than suffer compression.

As to the distinction between liquids and gases, it is necessary to state that liquids are, after all, compressible, though almost infinitely less so than gases. The compression of water is only perceptible under exceedingly high pressures. The compression of liquids at high pressure was the substance of a paper read by the Hon. C. A. Parsons and Mr. S. S. Cook before the Royal Society in May 1911, when it was stated that under a pressure of 4550 atmospheres water was compressed to 87 per cent.

Boyle's Law. We now come to a very celebrated law which was discovered by the Hon. Robert Boyle in the seventeenth century, and is now known by his name, dealing with the pressure of a gas. Boyle proved in his experiments "touching the spring of the air," that the volume of a given mass of gas depends on its pressure. Boyle's law may be stated in several forms. Perhaps the following is the simplest: If the temperature be constant the volume of a gas varies inversely as its pressure. This fact may be expressed in another way. For a given quantity of gas the product of the pressure and the volume is constant. The most popular statement of the law would run something like this: If we take a given quantity by weight of any gas we find that the greater the space it occupies the less is the pressure it exerts, and *vice versâ*. This exceedingly simple law may be taken as true for all practical purposes.

A cardinal difference between liquids and gases is that the latter alone always completely fill any space that may contain them. This fact, of course, is naturally associated with Boyle's law. Upon it depends the principle of the air pump. For if we connect an empty vessel with a vessel containing air, the air will at once fill both of them, and thus by a simple mechanical contrivance it is possible to reduce the amount of air in the vessel to an indefinite degree.

But by means of the air pump we can never hope to extract all the air from a vessel. Every time the pump is worked we can extract perhaps half the remaining air, but if we follow this out it will be seen that such a process will never result in completely emptying the vessel. Hence it is clear that a perfect vacuum can never be thus obtained; but a vacuum which is almost perfect can be obtained by the simplest means, and this is the Torricellian vacuum.

Behaviour of Gases and Liquids. In contradistinction to the behaviour of a gas which always fills any space in which it is contained, and which thus enables us to make air pumps, is the behaviour of a liquid, which always has a free surface. Such a surface is horizontal or level—at any rate, we describe it as such, and such it is for practical purposes; but, as a matter of fact, the surface of a liquid, even water in a tumbler, is not horizontal or level, but is curved, having a convexity which corresponds to, and is indeed part of, the general convexity of the earth. Every part of the surface of a liquid is at the same distance from the earth's centre, and thus the surface cannot be absolutely level, though it is practically so. If we place in a vessel two liquids which cannot mix, such as oil and water, we find that the surface between the two is practically horizontal.

Physics of Fluids in Motion. As the reader would expect, this part of our subject is known as Hydrokinetics; it is one of the most recondite parts of physics, and it is largely in order to simplify, as far as possible, the study of it that physicists have invented the conception of a perfect fluid, because when friction and viscosity are taken into account in the study of fluid motion, the whole subject becomes practically too difficult for prosecution; even the motion of perfect fluids is to be investigated only with very great difficulty. Perhaps the most important proposition in hydrokinetics is that arrived at by Torricelli, Galileo's famous pupil. It deals with the speed at which water flows out of an opening in a vessel. The student will be prepared to believe that the rate at which the fluid, say water, flows out will depend upon its pressure, and its pressure will plainly depend upon its weight. We can measure the speed at which water will fall freely from a height, and Torricelli showed that the speed with which the water will issue from the opening corresponds to a fall from the height of the surface of the water above the opening through which it issues. But complications arise. The actual speed at which the water emerges varies very greatly with the shape of the opening.

Limit of Speed Through Water. The last point to which we need refer is one to which allusion has already been made; it concerns the limits of attainable speed through water. The task which has to be performed by the engines of a ship is to overcome the resistance of the water—more accurately, we should say, by the engines of an already moving ship. Once the ship is in motion, as we have seen in our study of Newton's first law, it will continue to move for ever but for the external resistance, and it is that resistance that the engines have to overcome.

It might be thought that if engines of 1000 horse-power can develop a speed of, say, 10 knots an hour, it will only be necessary in order to develop double that speed merely to double the horse-power; but this is very far from being the case. In the first place, the resistance of the water to the vessel increases, not as the speed increases, but as the square of the speed—that is to say, if we double the speed, we quadruple the resistance. Further, it is obvious that the distance through which the resistance is overcome in a given time varies according to the speed. Hence, it follows that the horse-power necessary for any vessel must vary according to the *cube* of the speed desired. In other words, if we wish to double the speed of the vessel, we require, not twice but eight times the horse-power that we had before, eight being the cube of two.

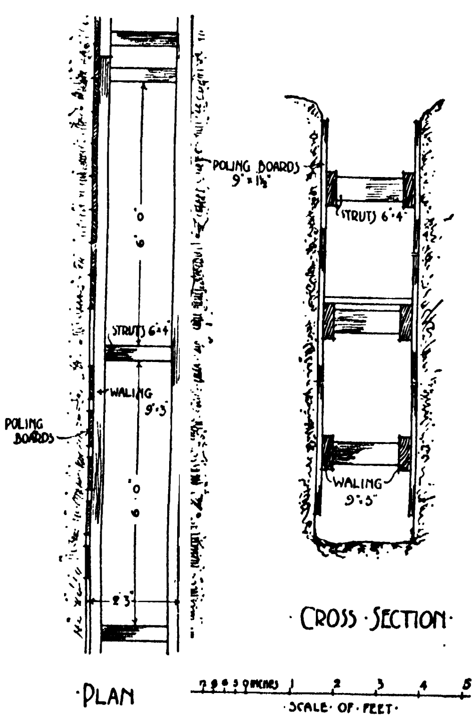
C. W. SALEEBY

The Work of the Excavator. Soils and their Bearing Power. Natural and Artificial Foundations. Piling and Underpinning.

LAYING THE FOUNDATIONS

Top Soil and General Levelling. In excavating a site it is usual first to remove any turf, setting it aside for relaying or sale. Turfs are usually three feet long, one foot wide, and are rolled. Gravel paths, flags, etc., may sometimes be similarly taken up and set aside. It is usual also to take up and set aside the top layer of earth if suitable for garden purposes. After this has been done the site must be levelled to the depths shown in the drawings.

In some cases a uniform level is required throughout. In other cases the level varies in different parts of the site. Hollows may require filling up, and in such cases the best of the material is selected for this purpose. The spoil, when excavated, increases considerably in bulk. Increase varies with different soils, but does not often exceed 20 per cent. Such material, if filled in again, gradually consolidates and contracts. To assist the process it is usual to water it liberally, and ram it. The settlement due to consolidation is usually not less than one inch in one foot, and may exceed this proportion considerably. Any material useful for building purposes—*e.g.* good gravel or sand free from loam or clay—may be put aside and used for building by arrangement with the owner.



4. TIMBERING TO A TRENCH

Trenches. When the general levels have been reached, any additional excavation for cellars, vaults, basements, etc., are made as well as trenches to receive the foundation and drains. Drain excavations are often deferred until the carcase of the building has been completed. All the excavations are sunk to the depths shown in the drawings. The trench required to take the concrete under a 9-inch brick wall is not less than 2 ft. 2 in. wide, just sufficient to allow a man to work in it; but he cannot throw out the spoil from beyond a depth of six feet, and if the excavation exceeds this, a stage must be provided on which he throws the spoil and from which it is thrown out, increasing the labour and the cost. An extra stage is required for every extra six feet in depth. In a ten-hours' day a good excavator can dig and throw into barrows eight to ten cubic yards of common ground, five to six cubic yards of stiff clay or firm gravel, and if hard ground, where the pick is used, three to five cubic yards. For deep drains tunnelling may have to be undertaken. This is done by sinking pits at convenient intervals and excavating short tunnels from one to the other. The width is determined by the nature of the work required. The height must be sufficient for a man to work in, and the sides are usually made to slope in towards the top of the tunnel.

In moist and wet soils water is liable to soak into excavations, especially in wet weather. All water must be got rid of by baling if the quantity is small, or by pumping if it is large. It should be constantly kept under, as it softens and deteriorates the surface of the trench.

Bearing Power of Soils. Trenches that have reached the depths shown upon the drawings should have the bottoms carefully tested to see that the stratum of soil is of a character suited to carry the load to be placed on it. In ordinary cases this may be done by driving in a crowbar to test the solidity of the ground, and on sites previously occupied an examination must be made for old and disused drains, wells, and cesspools, which, if built over, might collapse. Such drains or cesspools should be cleared away. Any old foundations should be grubbed up and cavities filled with concrete if walls or piers are to stand over them. Otherwise they should be filled with hard dry brick rubbish. Where the bearing capacity of the ground requires to be carefully tested, a strong platform with legs framed to it at the four corners may be used. If 6 in. by 6 in. legs are used, the area of the four together should equal one foot

superficial, and the table can be loaded with any convenient heavy material. The ground is carefully levelled and the table placed in position.

The level of each corner having been taken in relation to some fixed datum, the load is applied gradually, evenly, and without shock; the levels are taken again from time to time, and the load is increased until variation is noticed. From one-fifth to one-half of the load required to produce settlement is taken as the safe load. If the load to be carried exceeds the safe load, a stronger stratum must be sought, or the weight per foot reduced by an increase of the area of the bearing surface.

TABLE OF BEARING POWER OF SOILS

MATERIAL This table is from a "Treatise on Masonry Construction," by Ira O. Baker	Bearing power in tons per square foot.	
	Min.	Max.
Rock, hard	25	30
,, soft	5	10
Clay in thick beds always dry	4	6
Clay in thick beds moderately dry ...	2	4
Clay, soft	1	2
Gravel and coarse sand well cemented	8	10
Sand, compact and well cemented ...	4	6
,, clean and dry	2	4
Quicksand, alluvial soils	½	1

Small sections of soft ground are sometimes found in trenches otherwise satisfactory. These may often be dug out to a sound bottom and filled with concrete without deepening the whole trench. On a sloping site it may be necessary to introduce steps into the trenches, but in all cases the bottom of the trench for foundations should be kept level; those for drains may be excavated to conform to the fall in the drain.

The concrete should be laid in the trench as soon as possible after opening to protect the foundation from the weather.

Timbering. Where it is necessary to carry excavations perpendicularly or nearly so, as in trenches or for cellars, means must be taken to support temporarily the face of the earth which is liable to crumble away or be forced into the trench. In some shallow excavations this precaution is not necessary if the trench is to be open for a short time only, but in loose soils even shallow trenches, and in all soils deep trenches, must be protected. This is done by *timbering*.

The nature of the work depends on the character of the soil. Good soils are usually natural or *virgin* soils that have not been disturbed and include dry clay. Moderate soils include ground that has been filled in (termed *made ground*), loose gravel, while treacherous soils include sand, wet clay, all water-logged soils, and even ordinarily good soils if trenches are dug near ground which is supporting very heavy buildings.

The materials used for timbering are *poling boards*—*i.e.* short lengths of board usually 9 in. by 1½ in. and 3 ft. long, but sometimes longer, placed vertically against the sides; *waling pieces*, which are horizontal timbers usually 9 in. by 3 in., placed about the centre of the poling boards, and *struts* to keep the whole in position.

Methods in Different Soils. In good soils continuous timbering may not be required if the trench is not very deep or wide. In such cases a pair of poling boards are placed against each face of the excavation opposite each other. The strut is cut about half an inch or three-quarters of an inch longer than the distance between the boards inserted between them and forced into a horizontal position with the help of a heavy hammer. Pairs of boards thus fixed may be placed at intervals of about six feet. If placed closer they impede the excavator in his digging, and if they do not suffice to keep the sides intact, a different system must be adopted. The poling boards are then placed with only short intervals between them, or in some soils actually touching. Strong horizontal timbers termed *waling pieces* are placed in front of them at about the centre of the height and secured with struts, as already described. In a long trench the waling pieces have to be joined and a strut is placed close to the end of each length [**4**], with intermediate ones at intervals of six feet. Such timbering is put into position and secured as soon as the trench is of sufficient depth—about three feet—and before any further ground is excavated. As the digging proceeds in deep trenches, similar timbering is placed below the first in successive stages as required, care being taken to keep the struts vertically below those above.

In some soils the vertical face cannot be relied upon to stand safely even while a three foot trench is being dug. In such cases, in place of vertical poling boards, horizontal planks (termed sheetings) are placed in position as soon as from nine inches to twelve inches in depth has been excavated and temporarily strutted. Then, when another layer is removed, a second board is placed below the first and strutted, and so on, until a depth of about three feet has been reached. Vertical walings are then placed in front of the boards and secured with struts, the temporary ones being afterwards removed. A greater depth may then be got out and protected in the same way. The platforms or stages required in deep trenches for throwing out the spoil may be carried on the waling pieces.

Water-logged Ground. In water-logged ground special precautions must be taken, and heavy and very sound timber used. Longer boards, usually 11 in. by 3 in. and up to eight feet long, are used in place of poling boards, and are termed *runners* [**5**]. The feet are cut to an inclined chisel edge and in strong ground shod with iron, as in sheet piling. In fixing after ground is excavated as far as is safe, guide runners, about ten feet apart, are driven in by mallets and strong waling pieces fixed and strutted. Other runners are inserted and driven in until a continuous wall is formed. Excavation then proceeds until within about a foot of the bottom of the runners, when they are driven further down, additional walings inserted, and the struts increased with the depth.

In a deep trench, if a second set of runners (or

more) is required, they are not set under the upper ones, but within them, so that the width of the trench is narrowed, and allowance for this must be made in setting out the upper trench. The heads of the lower runners must not be driven deeper than about 12 inches above the feet of the upper runners.

Tunnelling. Where tunnelling is employed, similar precautions must be taken. A shaft is sunk to the required depth, the tunnel is worked in from the face, a beginning is made at the head, and as soon as the roof shows any signs of insecurity poling boards are driven in close against the roof and supported by a cross-beam or *header*, the ends of which are strutted from the floor, the feet of the struts being let into it to prevent accidental disturbance.

Poling boards can be driven in behind the struts [6]. Excavation then continues until another set of poling boards and frame can be inserted. In very bad or wet soil a more elaborate plan is necessary. The poling boards are longer, and directly supported by squared timbers arranged as a frame. These in turn are supported by horizontal pieces, which are themselves strutted by a very strong frame, often including a sill to take the feet of the struts, which must be sunk below the floor level. Notches are cut in the heads and sills and the struts fitted to them, but large spikes are sometimes used for increased security.

Large excavations also require to have the sides timbered; the system is generally similar, but the walings are usually heavier, and the struts are formed of large timbers and are tightened with folding wedges [7]. In excavations too wide for strutting the walings require to be supported by shores [see SHORING] placed at intervals along the sides of the excavation.

Natural Foundations. The natural soil on which a building rests has to bear the whole burden of the superstructure, which must be disposed so as not to cast too heavy a load on any part of it. Every wall is required by the London Building Act and by most Local Acts to have footings [see BRICKLAYING] equal in width to twice the thickness of the wall, and in addition, with a few exceptions, to have a slab of concrete under it at least eight inches wider than the footings. For fairly good soils and with ordinary buildings of moderate height this secures a sufficient distribution of the load for security.

In the case of buildings in which different parts are unequally loaded and where heavy loads are carried by detached piers or stanchions, it is important not only that the load should not exceed the bearing capacity of the soil, but that the pressure upon it should be as nearly as possible equal at all points; so that should any settlement occur in the foundations, it will be uniform, otherwise the more heavily laden parts will be the most liable to sink, producing cracks in the superstructure.

It is therefore necessary to calculate the actual weight of materials supported by each square foot of brick or stone in the general walls, as well as in the piers, and to regulate the area of the concrete under them so as to produce a uniform pressure. In this calculation must be included the proportion of every floor area and of the roof carried by the wall or pier, including the load it is intended to carry.

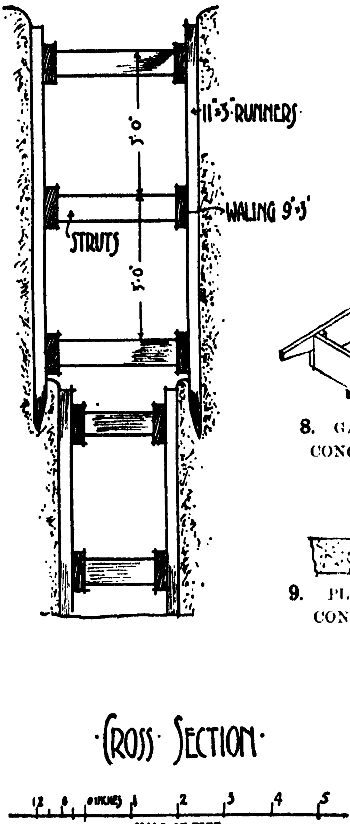
For domestic buildings an allowance of 1 cwt. per foot super of floor, including the load, is an ample allowance, though 1¼ cwt. is often allowed. For public buildings 1½ cwt. per foot super, including the load, is allowed. For warehouses and other special buildings it is necessary to ascertain the actual load to be carried, which is often from 2 cwt. to 3 cwt., and may be as high as 6 cwt., per foot super.

Rock. Of the various soils usually met with in foundations, the strongest is *rock*. This will support any load that is likely to be put upon it, even if not a strong rock, and makes an excellent foundation if it entirely covers the site. Many rocks are apt to hold water in pockets and fissures, and means must be taken to get rid of this by giving the surface a slight inclination and arranging for the discharge to a suitable spot of any water that collects.

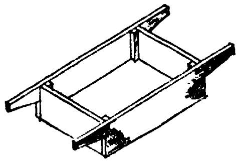
Any loose or decayed material on the surface must be cleared off, and if the surface is not level the stone must be worked into level beds under the footings and stepped where necessary. Holes and fissures may be levelled up with cement concrete, or, if large and deep, may be arched over in stone or concrete unless they come directly under a heavily loaded pier. Should the rock only extend over part of the site, the remainder being of some less solid material, the foundation is by no means easy to deal with, and great care must be exercised to give a sufficient bearing to the portions of the building on the weaker soil, or an unequal settlement may develop which will crack the building.

Clay. Clay varies greatly, according to its nature and position. The blue London clay forms a first-rate foundation, but is only encountered as a rule at considerable depths. The ordinary yellow clay varies greatly. It will sustain any reasonable load if fairly dry and not subjected to influences that will change its condition. It is essential to carry down excavations below the level at which it is affected by changes of weather and climate, and for safety this may usually be taken at five feet or more below the surface. Clay that is liable to be reached by an excess of water becomes soft and plastic, and will squeeze out under pressure, and trenches in clay in particular should be concreted as quickly as possible. There is the further liability on sloping ground that excavations may be opened at a lower level, drain the moisture from the subsoil, and so produce subsidence, and in consequence of its liability to change with altering circumstances the yellow clay should be looked upon as a foundation which requires very cautious handling.

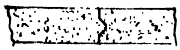
Gravel. Gravel is one of the best foundations after rock. If compact, and where an entire foundation consists of this material, footings may be constructed on it without concrete beneath them. The gravel must not, however, be in a position where it is subject to



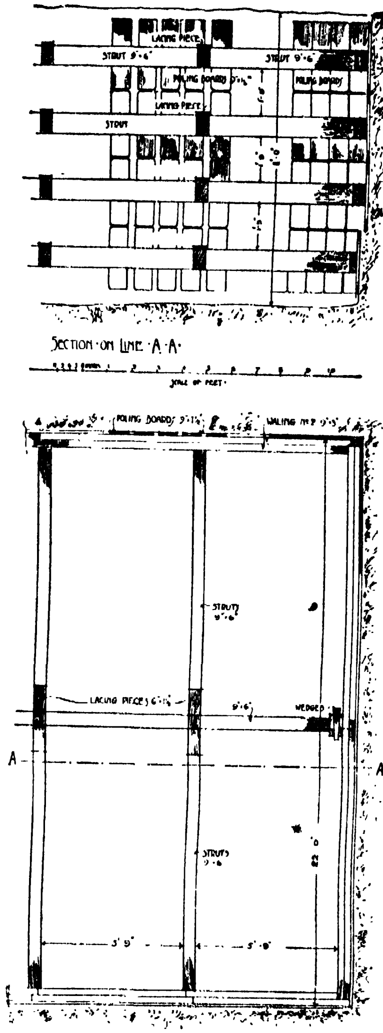
5. TIMBERING TO A TRENCH IN BAD SOIL



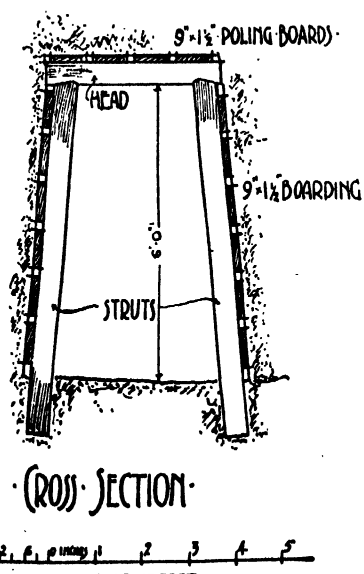
8. GAUGE-BOX FOR CONCRETE-MIXING



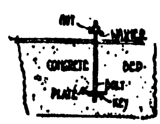
9. PLAN OF VERTICAL CONCRETE JOINT



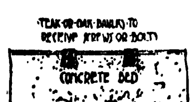
7. EXAMPLE OF TIMBERING FOR A LARGE EXCAVATION



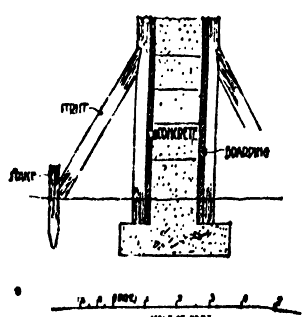
6. TIMBERING FOR A TUNNEL



10. HOLDING DOWN BOLT IN CONCRETE



11. BEAMS IMBEDDED IN CONCRETE



12. METHOD OF FORMING CONCRETE WALL

DIAGRAMS OF PROCESSES IN EXCAVATING AND CONCRETE WORK

erosion by flowing water, or it must be properly protected from such action. Even loose gravel, if confined so that it cannot spread, forms a good basis for building, but a slab of concrete should be used.

Sand. Sand also makes a good foundation if it is confined so that it cannot spread and is protected from erosion. It is practically incompressible, but is easily washed away by running water. If the bottoms of the trenches require to be stepped or if a deeper excavation for cellars is required, care must be taken to prevent the sand in the upper parts from being forced out.

Chalk. Chalk varies considerably in quality and is liable to disintegrate if exposed to the action of the weather. The strata immediately below the top soil are often somewhat loose, but if excavations are carried below the weather line a very good sound foundation is usually reached. There are apt to be fissures and pockets of loose gravel and sand, which if they come under walls or piers should be emptied and filled with concrete, or, if the load is light, they may be covered with a thick slab of concrete. An exposed chalk face should be protected from the action of the weather by a facing of brickwork, stone, or flint.

Quicksand, Alluvial Soils, and Made Ground. Quicksand, alluvial soils, and made ground are all unsatisfactory as foundations. They are compressible, and made ground in particular is liable to contain putrescible material. Circumstances may arise in which buildings must be erected on such foundations, and in all such cases special precautions must be taken. The circumstances of each individual case must be carefully considered as it arises.

Made ground varies much in character. It may be the result of excavations for sand or gravel, which have been replaced by other hard dry material, which, with the lapse of years, attains very fair solidity, or it may be the result of a general raising of the level of a low-lying locality, such as has taken place in parts of the East of London. In the latter case, road sweepings, ashes, etc., are often employed, sometimes in a wet condition, when they will be offensive for a long time, and will never become well solidified. The presence of putrescible matter in the soil may be a source of danger to health, as the ground air under some conditions is drawn into buildings by the action of ordinary fireplaces.

Trial Holes. Before the building is designed, the nature of the soil, unless well known, must be ascertained by sinking square pits or trial holes at various parts of the site, noting the character of the strata pierced and seeing whether their character varies in the different pits. Where a soft stratum occurs above a hard one, it is as a rule desirable to sink the foundations to the harder bed, but where a hard stratum occurs above a soft one, it is often safe to build on the upper one, provided it is possible to leave a considerable thickness of it undisturbed. In such cases much will depend upon the building to be erected, and inquiry as to the circumstances of surrounding buildings must be made and judgment exercised. No hard-and-fast rule can be laid down. A thorough acquaintance with the nature and capabilities of the bearing stratum is not only necessary before the work is started, but should, when heavy loads have to be dealt with, be gained before the footings are designed.

Artificial Foundations. The footings of a wall or pier can seldom be laid on the natural foundation. Almost always some other provision must be made to receive them, and this must vary with the nature of the natural foundation and the load it has to bear. The loads to be carried due to walls and piers respectively having been calculated, the safe load that the natural foundation will sustain and the area of the bearing surface under each may be ascertained and the trenches excavated to the required size. With a good natural foundation, even when heavy loads are to be carried, a thick layer of concrete is the material usually employed. With poor and treacherous soils other methods must be adopted.

Concrete. Concrete is a material which, when first formed, is in a plastic condition, and can be filled into any prepared excavation or mould. Within a few hours it sets into a solid rock-like mass, and within a few days attains a very considerable strength, though its maximum strength is not reached for months. It is composed of some hard substance broken into small pieces termed the *aggregate*, forming the bulk of it, and of a binding material termed the *matrix*. The nature of the *aggregate* varies according to the purpose for which the concrete is to be used. For foundation work and walls nothing better can be had than stone ballast from a river or pit gravel. Shingle for many purposes is suitable, but the stones in it are not "sharp" or angular, as is desirable, and the presence of salt renders the concrete liable to show signs of damp in wet weather or in moist situations. Other substances used are broken stone, clinker, burnt ballast (only permissible if thoroughly vitrified), and broken brick and pottery, which must also be thoroughly burnt. Underburnt bricks or ballast are not suitable. An excellent concrete results from about 25 per cent. of good broken brick with some form of stone aggregate. Whatever the material, it must be broken up to pass some standard. A two-inch ring is very often specified. This secures a solid uniform material without cavities.

Concrete Floors. For concrete floors laid on the solid, similar aggregates may be used. For upper floors, roofs, etc., in fire-resisting structures, lightness is of importance. Coke-breeze and pumice-stone are often employed, and for such purposes should be broken fine enough to pass through a one-inch ring. This is termed fine concrete. For concrete stairs, pavings, etc., the aggregate consists largely of granite chippings.

If the aggregate does not contain sand, sand or some substitute must be added to the extent of about 25 per cent. to 30 per cent. of the total bulk. The object of the sand is to fill up all interstices and to give cohesion. It is essential that the aggregate should be clean, free from all animal and vegetable impurities, and

that the sand should be sharp and free from loam. If loam be present, the sand must be washed. Washing is done in a tub of water. A large circular sieve is used, and with the sand is dipped into water till submerged. It is rotated so that the loam is washed out, and the sand is then thrown out into a heap.

The Matrix. The matrix consists of hydraulic lime or Portland cement [see LIMES AND CEMENTS]. The proportion of matrix to aggregate varies with the nature of the matrix, with the situation of the concrete, and the work it has to do. In the case of lime, if only feebly hydraulic, the proportion should not exceed one of lime to four or five of aggregate. Such concrete is not suitable for use in very large masses or in moist situations. If eminently hydraulic it may be one of lime to seven of aggregate. With cement the proportion may be one of cement to eight or nine of aggregate for concrete walling, and one of cement to five or six of aggregate for wet foundations and for concrete flooring.

Water. The water used must be clean, and it is important that no more should be employed than is necessary for the proper mixing of the ingredients. An excess of water reduces the ultimate strength of the concrete. The method of mixing is as follows: The proportion of matrix and aggregate being fixed by the specification, square frames without tops or bottoms are made [**8**]; the smaller contains a single unit, say a yard, for the matrix, the larger the corresponding number of units required for the aggregate. If the aggregate is not formed with a single material, but has, *e.g.*, a certain proportion of brick mixed with it, this is most usually incorporated before the mixing of concrete itself begins, but if necessary three or more frames may be employed, each proportioned in capacity to the amount of material to be used.

A close-boarded floor is provided as close to the spot where the concrete is to be used as possible, or a floor of sheet iron is sometimes used. The frames are placed on it, filled up level to the top (but not heaped up), and then removed. The aggregate is spread out, the matrix spread evenly over it, and the two thoroughly mixed by being twice turned over with shovels, dry—*i.e.* without any water. They are finally turned over with the addition of the necessary water, forming concrete, which is at once conveyed to the spot where it is to be deposited. In the case of trenches for foundation work, it may sometimes be thrown in by shovels direct. More usually it is filled into barrows, wheeled and tipped in. This must not be done from any great height, or the larger stones will collect at the bottom and the mass not be homogeneous.

Depth. If the depth of concrete is not great, say, 12 in. to 18 in., the full depth may be at once placed in the trench, in which stakes are driven and carefully levelled, marking the top of the concrete, which is spread and levelled by a labourer standing in the trench as soon as it is deposited, and should not afterwards be disturbed. Where a deep bed of concrete is required, it is usual to deposit it in successive layers of about 12 in. at a time. In the case of deep trenches the concrete must be lowered in bags or in barrows to a stage from which it can be tipped. Concrete should not be deposited in trenches containing water, which is apt to wash out the cement, leaving the lower part of the concrete poor. Water, however, does not interfere with the setting of concrete mixed with eminently hydraulic lime or cement. If used under water, it must be lowered in sacks and the surface protected till setting occurs.

Where a horizontal bed cannot be completed without interruption, it is usual to form the end with a V-shaped recess on plan [**9**] to give a vertical key to the next layer of concrete, and if this is not put in till the first is dry, the joint should be well wetted before the new concrete is deposited. Where successive layers are used, care must be taken that no mould from the trench or dust or rubbish is left on the upper surface of the old bed before the new concrete is deposited. The top surface of the final layer is levelled and smoothed over to receive the brick footings.

Concrete over Site. The concrete which is usually spread over the whole site within the walls, and which may form the bed for solid floors, or may be some distance below boarded floors, is usually cement concrete not less than six inches thick, spread uniformly, and with the upper surface smoothed over with a spade or shovel. Upper floors are filled in on a centre. This may be a close-boarded, flat, wooden centre [see CENTERING], or may consist of terra cotta lintels, iron sheets, etc., which remain as part of the floor. When concrete is used in this way in combination with iron or steel joists, it must be well rammed around the flanges.

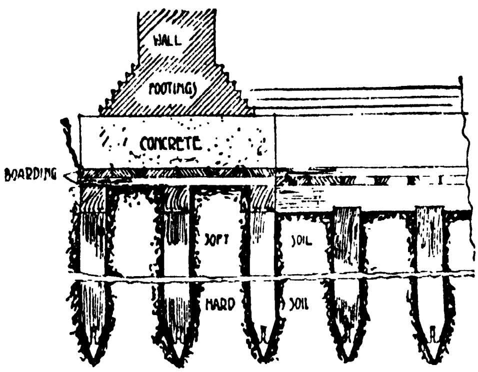
Concrete may also be filled into moulds, and when set used as blocks for building or as lintels, channels, etc. Concrete walling may also be cast in position. In this construction the space to be occupied by the wall is enclosed with close boarding fixed to upright posts, well tied and strutted, and the concrete is filled in in layers of about twelve inches at a time [**12**]. This is often done for retaining walls, but buildings of concrete have even been constructed in this manner.

In the case of concrete masses intended to receive heavy machinery provision must be made for securing the machinery. This may be done by building in iron or steel girders, to which they are bolted, or by building in holding-down bolts with anchor plates [**10**], and in all such cases templates giving exact position of bolts must be obtained from the firm supplying the machinery. Pieces of timber dovetailed in section are sometimes built into concrete beds standing above the surface of the concrete for lighter machinery [**11**], and are useful where machines must be shifted [see also FIRE and FERRO-CONCRETE].

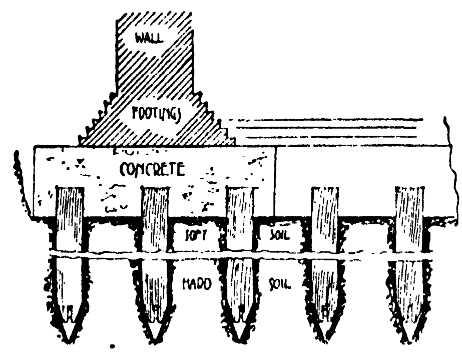
Foundations on Compressible Soils. Such foundations, even for heavy buildings, are sometimes inevitable, and in such cases means must be taken to render the natural foundation capable of supporting the superincumbent load. The circumstances are so varied that we cannot deal exhaustively with every

case, but must refer to the general methods of dealing with this difficult problem. Such foundations are costly, but the cost must be faced.

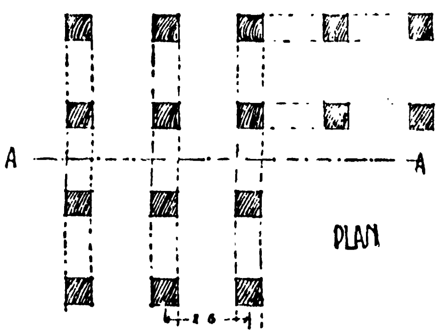
The method will depend upon the nature of the site. If the compressible stratum overlies a good solid stratum, but the latter is so deep that the cost of taking down the walls of the building is prohibitive, it may nevertheless be possible to take down piers of concrete or masonry to the lower level at short intervals and to throw arches or girders from pier to pier to carry the walls. This is only possible when the soft stratum is of a character that will permit of shafts being sunk, and cannot be employed for anything in the nature of quicksand or water-logged strata.



13. PILING WITH TIMBER PLATFORM



14. PILING WITH CONCRETE PLATFORM



15. PLAN OF PILES UNDER A WALL AND CROSS-WALL

The area of such piers must be proportioned to the loads to be carried. The bottom must be carried well into the solid stratum and the piers carefully constructed. Their spacing must depend upon the nature of the building to be supported, but they will not be, as a rule, more than ten feet apart in the clear. Iron screw-piles may sometimes be employed in such circumstances spaced at greater intervals, and the tops connected by heavy girders.

Piling. When the soft stratum is very deep or very treacherous, say 30 ft. or 40 ft., the system of piers is not suitable, and in such cases long piles may be driven through the treacherous ground into the solid stratum below. In America, where buildings of great height are erected, it is frequently the custom to drive in piles two to three feet apart centre to centre in rows spaced at intervals of about 2 ft. 6 in. centre to centre over the entire surface of the site. In most cases it may suffice to drive two or three rows of piles under the lines of the main walls [15]. Care must be taken to cut off the tops at such a level as to be below that at which water stands, for if the tops are dry they will decay. The piles may be capped with granite blocks, each of which rests on two or three piles, but not on more, owing to the difficulty of securing even bearing. The footings are started above the granite. Another method is to excavate the ground for a depth of 12 inches between the piles, to fill in between them with good cement concrete in layers, and to raise the concrete about 18 inches above the level of the pile head [14]. The concrete filling up to the level of the heads may be usefully employed under granite capping.

A third method is to connect the heads of the piles with heavy timbers, say 12 in. by 12 in., secured with bolts to the piles and running in the direction of the rows, and upon these to lay strong transverse timbers to receive the concrete [13]. In this case all such timbers must be kept below the water level. In the case of foundations which are liable to spread—such as sand with water—but which if confined will carry considerable loads, the whole area of the site may be surrounded with sheet piling, and the site covered with a thick bed of concrete. When the depth of the soft ground is so great that solid ground cannot be reached, piling may still be resorted to, but the piles will not carry so great a load as if driven to the solid.

Underpinning. Underpinning, which consists in carrying down an existing wall to a greater depth and providing it with a new foundation without disturbing the superstructure, is often necessary. A heavy superstructure must be *shored* and perhaps *needled.*

The old footings and concrete must usually be cut away, the excavation to receive the new work carried down in short sections at a time, [see BRICKLAYER]. When the first series of excavations have been made, and the work set, the intermediate pieces are dealt with. Great care is required to see that the concrete surfaces between the successive blocks are clean and a good junction is made. R. ELSEY SMITH

Natural Agents Engaged in Dispersing Seeds. Action of Water and Wind. The Part played by Insects, Birds, and Animals.

HOW FLOWERS COVER THE EARTH

We have now considered in some detail the means by which the continuance of the species is effected. But as plants are not able to move about actively, it is necessary that there should be some provision for dispersal of their offspring, so that some at least of them may be able to find a suitable spot where they can grow up. Certain species actively disperse themselves, while others are scattered by water, wind, or animals.

How the Plants Form Colonies. There are many plants which send off more or less horizontal branches below or above the ground, from the nodes of which roots grow down and shoots grow up, so that a sort of colony is produced, with members which may be arranged in a row or in a cluster. The cases of the sand-sedge (*Carex arenaria*) and strawberry (*Fragaria vesca*) have been spoken of elsewhere. Other familiar examples with underground stems are mint (*Mentha*), millefoil or yarrow (*Achillea millefolium*), reed (*Phragmites communis*), couch-grass (*Agropyrum repens*), stinging nettle (*Urtica dioica*), butter-bur (*Petasites officinalis*), and coltsfoot (*Tussilago farfara*). The last four are well-known weeds which it is difficult to eradicate, owing to the way in which their numerous underground stems tunnel through the soil.

A variation on the arrangement just described is seen in tuberous plants such as the potato (*Solanum tuberosum*), where underground branches swell up into tubers, from the "eyes" or buds of which new plants arise. If forms such as these are left to themselves, clustered colonies will soon be produced.

The dark-green "fairy rings" which abound in rich pastures are mostly formed by toadstools, which spread outwards from a centre, exhausting the ground as they do so. There are, however, some seed-plants in which the same habit is observable, the ring being due to the death of older members of the colony which once occupied the middle of the patch. The Swedish fairies are popularly supposed to be especially fond of holding their midnight revels within the rings formed by a kind of grass (*Sesleria cærulea*).

Plants which Sow their own Seeds. There is a kind of clover (*Trifolium subterraneum*) in which the pods produced on the lower part of the plant bend down towards the ground, into which they are forced by the growth of the branches that bear them. In a kind of vetch (*Vicia amphicarpa*), native to South Europe, some of the flowers are self-fertilised and borne on underground shoots. Some detached fruits bury themselves in the ground. That of storks-bill (*Erodium*), for instance, possesses a spirally twisted awn, which uncoils when moist, and pushes the fruit into the earth.

The fruits of a number of plants are in a state of tension when ripe, and finally open or split suddenly in such a way as to eject the seeds to a considerable distance. One of the commonest examples is afforded by broom (*Sarothamnus scoparius*), the flat, black pods of which may often be heard exploding in late summer, the two halves curling up so that the seeds are scattered in all directions. A similar case is that of balsam (*Impatiens noli-me-tangere*), the ripe capsules of which split into four twisting strips at the least touch, with the same result. The seeds of wood-sorrel (*Oxalis acetosella*) suddenly fly out from the mature capsule [117], owing to the rapid swelling up of a layer of the seed-coat, which is in a state of compression. The squirting cucumber (*Ecballium elaterium*) of South Europe [116] presents us with a different kind of mechanism, for when ripe it is, so to speak, over-full of fluid, and, as a result, the stalk is suddenly forced off and the seeds squirted out.

How Seeds Spread over the Earth. *Sling fruits* resemble some of the preceding in certain respects, but owe their name to the way in which the seeds are propelled. In the marsh cranesbill or geranium (*Geranium palustre*), for example, each of the five compartments of the fruit is continued into an elastic fibre running up the beak like a prolongation, which has suggested the popular name [124]. The compartments with their fibres ultimately curl up suddenly, owing to the elasticity of the latter, and the seeds are flung for a distance. Acanthus [120] behaves in much the same way.

In many *catapult fruits*, the ripe seeds, or, it may be, parts of the fruit, are contained in an open cup, and get thrown out by the quick recoil of the very elastic stems and flower-stalks when these are moved by the wind or brushed against by animals. In wood-sage (*Teucrium*) and other members of the dead-nettle order (*Labiatæ*) this cup is the calyx, in which the little separate divisions (nutlets) of the fruit are contained, while in various species of the poppy, lily, iris, pink, primrose, or foxglove kind, the dry fruit splits or opens to form a cup or hole-pierced capsule, and it is the seeds which are shot out.

Flipping fruits include cases where the fruits are exceedingly smooth, and are pinched by contracting parts of the open fruit so as to be flipped to some distance, just as orange-pips can be shot from between the thumb and forefinger. An easily observed instance is that of dog-violet (*Viola canina*), where the capsule splits into three parts, within each of which are two rows of shining seeds [118].

The Coco-nut Palm's Sea Voyage. The dispersal of plants by water is the method naturally adopted in the case of some of the plants which live and ripen their fruits in running water, but the method is not limited to them alone, for it may occur in some land

forms. A notable case is that of the coco-nut palm, the fruits of which are invested in a thick, fibrous husk, entangling hair, and covered with a tough skin. They may be carried for thousands of miles by ocean currents without getting water-logged or losing their power of germination, and it naturally follows that this palm is one of the commonest forms of vegetation on the coral islands of the Pacific.

The name *roses of Jericho* was applied in the Middle Ages to two plants native to the steppes of South-east Asia and North Africa. One of them (*Anastatica hierochuntica*) belongs to the wallflower order (*Cruciferæ*), and, when its fruits are ripening during the dry season, the branches curl over them so as to give a remote resemblance to a rose that has not yet opened. When the rainy season sets in, the branches spread out, the fruits open, and the seeds are washed out, as shown in figure 127.

Plants Dispersed by the Wind. Some of the plants native to the steppes of Russia and South-west Asia form a rounded branching mass, which is easily detached from the root at the time when the fruits are maturing, and gets rolled like a ball along the ground by the wind. A good example is a species of plantain (*Plantago cretica*), and there are a number of others. As great numbers of such plants often stick together to make up a very large and increasing mass, which may at times be caught up into the air, they have become objects of superstition, and have given rise to legends of wind or steppe witches. Other species growing in similar localities produce round and very light fruits, which are easily blown along the surface of the ground for great distances.

There are some plants which produce innumerable flattened seeds of such small size that they can be blown about like grains of dust. Orchids afford the best example, and it is easy to see how the tropical members of the group get dispersed among the branches of the trees where they mostly grow. For an extreme case, it has been calculated that over 30,000 seeds only weigh one grain.

In a large number of trees, tall shrubs, and herbs, the fruits or seeds are provided with membranous expansions which are easily caught by the wind. The "keys" of maple, sycamore [125], ash, and elm are common examples of winged fruits, while in hop, lime [119], and hornbeam a bract serves as a sail. The Scots pine (*Pinus sylvestris*) and the spruce fir (*Abies pectinata*) will serve as good examples of winged seeds.

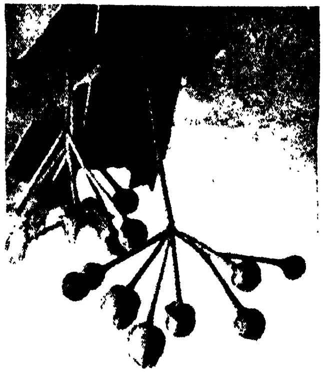
In many members of the dandelion order (*Compositæ*) the calyx is transformed into a beautiful crown of hairs ("pappus"), which serves as a parachute. The dandelion itself [122] (*Taraxacum officinale*) is a particularly instructive example. While the head of crowded yellow florets is maturing the stalk is short and near the ground, but it elongates and stands erect when the florets open to attract insects. Pollination and fertilisation accomplished, the stalk moves down so that the fruits can ripen in comparative safety close to the earth. When this is accomplished, the stalk once more becomes vertical, the crowns of hair spread out, and the fruits of the "dandelion clock" are blown

116. SQUIRTING CUCUMBER DISPERSING SEEDS

117. WOOD-SORREL EJECTING A SEED

VARIOUS EXAMPLES OF SEED DISPERSAL

118. DOG VIOLET



119. LIME

120. ACANTHUS

121. PLANE

122. DANDELION

123. WILLOW-HERB

124. MARSH CRANESBILL

125. SYCAMORE

hither and thither by every wind that blows. Equally familiar and of the same nature is "thistledown," while the parachutes of goats-beard (*Tragopogon*) are noticeable on account of the extreme beauty of their feathery hairs. The elegant fruits of clematis are also wind-dispersed, and so are those of the plane-tree [121]. Of tufted seeds it may suffice to mention willow (*Salix*), cotton (*Gossypium*), and willow-herb (*Epilobium*) [123].

The chief groups of animals which unconsciously assist plants to colonise in favourable places are insects, birds, and mammals.

In warmer climates than our own, there are several species of ants which may almost be described as farmers, for they collect and store various grains and seeds for consumption during hard times. A certain proportion of these must frequently escape being eaten, and grow up into young plants.

126. HARPAGOPHYTON

A very extraordinary case is afforded by the seeds of violets and pansies, each of which possesses a small, fleshy knob (caruncle), which serves as a sweet and toothsome food that appeals to the taste of certain ants. They are thus tempted to carry off these seeds, which remain quite uninjured when their little knobs have been gnawed away, and germinate if surrounding conditions are favourable.

The earth which often clings to the feet and feathers of birds, especially those which seek their food in damp places, often contains large numbers of small seeds, which thus stand a chance of getting carried to spots where they may successfully germinate and grow up. But a more frequent and more important case is that of succulent fruits, such as grapes, sloes, and a large assortment of berries, which attract birds by their often brilliant colours, and minister to their appetites. In such fruits we find that the seeds are commonly protected by strong coverings, which protect them from the processes of digestion, so that they are voided in a fit state for germination where they fall.

127. THE ROSE OF JERICHO CLOSED AND OPEN

Many of the brightly coloured edible fruits of hot climates appeal to monkeys as much as birds, and thus get their seeds distributed in similar fashion. We also find a great variety of fruit and seed upon plants of low stature, provided with devices of various kinds by which they are enabled to cling to the coats of their unconscious friends.

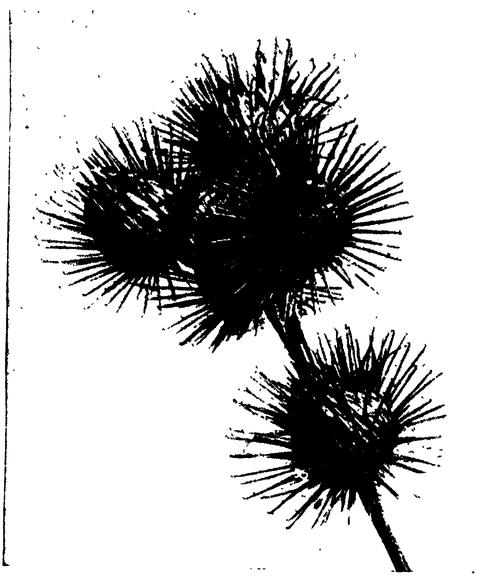
It has been estimated that some 10 per cent. of all flowering plants produce fruits provided with hooks or spines by which they easily get attached to fur or hair [128-133]. Familiar examples among our native plants are burdock (*Arctium lappa*), agrimony (*Agrimonia eupatoria*), avens (*Geum urbanum*), and cleavers or goose-grass (*Galium aparine*). Some arrangements of the kind possessed by foreign forms are of truly formidable nature, such as the strong, curved hooks of martynia, native to Louisiana, and the numerous formidable claws of harpagophyton, a plant which flourishes in South Africa, and is said to be fatal to the lion by producing festering sores [126].

Nature's Ingratitude. We also find that the spiked iron balls known as caltrops, which mediæval generals scattered on the ground for the entertainment of hostile cavalry, have been anticipated by some plants for the more useful purpose of dispersing their fruits. In Hungary and elsewhere, for example, there are forms (species of *Tribulus*) in which the fruits break up into pieces that lie on the ground and are liable to penetrate the feet of sheep and horned cattle by means of a sharp, brittle spine which sticks up from each of them. After being carried away, the seed-containing part breaks off, while the spine remains embedded in the foot of the friendly animal, setting up a painful, festering wound—a very ungrateful return for services rendered.

Sticky fruits are provided with sticky patches or hairs which easily adhere to the coats of passing animals. Typical examples are a kind of sago (*Salvia glutinosa*), and plumbago, a plant often grown in greenhouses in this country. It may be well to add that hooked and sticky fruits often attach themselves to the feathers of birds as well as to the fur of mammals, a fact which greatly assists in the wide dispersal of certain plants.

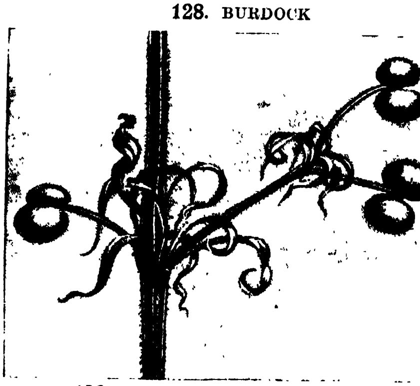
J. R. AINSWORTH-DAVIS

CURIOUS FRUITS WITH HOOKS AND SPIKES

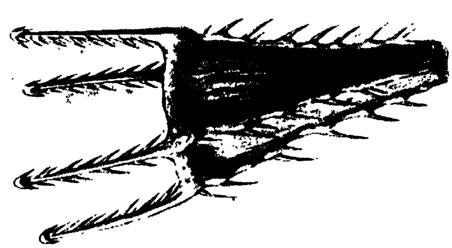


128. BURDOCK

129. AGRIMONY

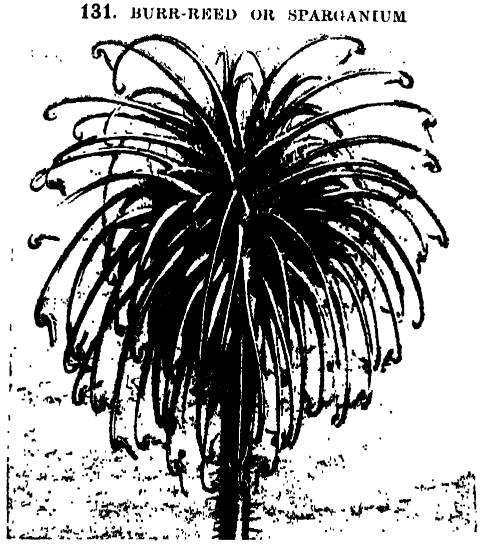


130. GOOSEGRASS OR CLEAVERS



131. BURR-REED OR SPARGANIUM

132. AVENA

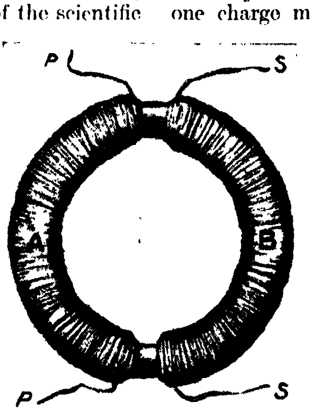


133. COMMON AVENS

Induction. The First Transformer. Attempt to Convert Magnetism into Electricity. Faraday's Primitive Dynamo.

FARADAY'S DISCOVERIES

Faraday's Researches. To Michael Faraday (1791–1867) more than to any other of the pioneers of electricity are electrical engineers, and, indeed, the whole world, indebted for the discoveries upon which the advances of modern times and the inventions of recent years are based. The chief discoveries which he made in electromagnetism, the foundation principles of all transformers and of all dynamos, were made in the autumn of 1831, the first fruits of his resolve to abandon the lucrative work of a professional expert in order to devote himself to scientific research. He had indeed already achieved fame by earlier researches, chief among them being the discovery of the electromagnetic rotations—the principle, in short, of electric motors—the chemical discovery of benzol and the liquefaction of chlorine. But it remained to him to discover, what had long eluded the grasp of the scientific experimenter—namely, the use of magnetism to generate currents of electricity. For at that date the only known ways of generating electric currents were (1) the chemical method in the voltaic cell, (2) the thermal method by the heating of the junctions of different metals, (3) the frictional method, as in the old glass electric machines. The first of these depended upon the consumption of zinc and acids in batteries; the second yielded very small electromotive forces, and was uneconomical; the third gave sparks and discharges rather than useful currents, and was unpractical. To these three Faraday added a fourth when he found that an electric current was generated in a copper conductor, mechanically, when the conductor was moved past the pole of a magnet, or when the magnet was moved near the conductor. Incidentally he discovered a great deal more than this; but the main point is that stated. For if we had had to depend on chemical action, thermal action, or friction, for our supplies of electric current, there would have been to-day neither electric light nor electric motive power. The public supply of electricity from central stations, and all the thousand applications in electrical engineering would have been quite out of the question.



43. FARADAY'S RING

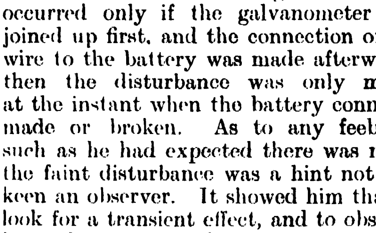
Induction. In the earlier-discovered phenomena of electricity the only known ways of producing a current in a copper wire had been by contact or conduction—the current could be conducted from one piece of metal to another. Also it was known that magnetism could be conducted along an iron bar by placing it in contact with the pole of a magnet. Conduction along the metallic substance from particle to particle was a familiar idea. It had also been known for half a century that an electric charge could be acquired by a body *by influence* from a pre-existing charge of electricity in another body, at a distance of a few inches apart, without any contact or communication between the two. To this phenomenon of action at a distance, discovered by John Canton, the name of *induction* had been given, to distinguish it from conduction. It was also known that magnetism could be imported, by influence, from a magnet to a neighbouring piece of iron without contact or conduction, and this was similarly called magnetic *induction*. But though one charge might induce another charge, and one magnet might induce another magnet, no one had ever been able to make an electric current induce another electric current, nor had anyone succeeded in causing a magnet to induce a current. Many philosophers had expected that some such relations would exist. They had tried to observe them experimentally. Faraday himself had both expected and experimented. In 1822 he wrote in his note book as a thing to be tried: "Convert magnetism into electricity." A splendid problem—but how to do it? In 1825 he tried several times, but without result, and again in 1828, for the fourth time, but fruitlessly. But in August, 1831, he began a systematic research, from which in a brief ten days of work, with intervals of contemplation and preparation between them, he emerged triumphant.

Induction from Wire to Wire. The idea, suggested by analogy, was that if there were two wires lying side by side, and if along one of them a powerful enough current were flowing, there would be some current induced in the neighbouring wire; but no experimenter, not even Faraday himself, had been able to observe such a thing. Again, it had been argued, by analogy (but incorrectly), that if an electric current circulating around a coil of wire, placed so as to surround a bar of iron could make that bar into a magnet (see page 495), then, as a deduction, if we were to put a powerful enough steel magnet inside such a

coil of copper wire, the magnet ought to induce a current of electricity in the coil. But it did not when the experiment was tried. How to convert magnetism into electricity still remained a problem.

When Faraday set to work he began by coiling wires round wooden rods and wooden blocks; two wires, not touching one another, being carefully coiled side by side so as to lie close beside one another. He joined up one wire to a battery so that a current flowed along it. Then, joining up a galvanometer to the second wire, he looked to see whether any trace of current was "induced" in the second wire by the influence of the current in the first wire—and there was none. He varied the experiment in several ways, but obtained no success beyond a faint disturbance in the galvanometer, which occurred only if the galvanometer wire was joined up first, and the connection of the other wire to the battery was made afterwards; and then the disturbance was only momentary, at the instant when the battery connection was made or broken. As to any feeble current such as he had expected there was none. But the faint disturbance was a hint not lost on so keen an observer. It showed him that he must look for a transient effect, and to observe it the better he constructed new apparatus. This was tried on August 29th, 1831.

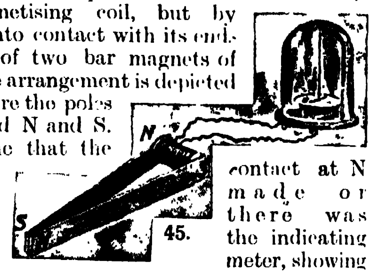
Faraday's Ring. Faraday had made a ring [43] of soft iron. It was forged by a blacksmith of iron rod ⅞ inch in thickness, and was 6 in. in external diameter. On this ring were wound two coils (A and B) of insulated copper wire; there being 72 feet in coil A, and 60 feet in coil B. This ring was used as follows. A battery of ten small cells was prepared to be connected to coil A, while coil B was joined to a simple galvanometer made of a coil of wire passing over and under a compass needle. On *making* the circuit between coil A and the battery [44] there was an immediate and transient effect on the galvanometer in the B circuit; its needle was deflected, oscillated, and finally settled down in its original position. On *breaking* the connection with the battery, the galvanometer again showed a temporary disturbance, but the deflexion was in the direction opposite to that of the deflexion which occurred on making the circuit. As the two coils A and B were quite separate, electrically, from one another, it was clear that the current in A had *induced* currents in the coil. It was also clear that the iron ring had a share in the operation. In fact, when the current in A was turned on, the circulation of the current in the A coils had magnetised the ring; and when the current in A was turned off, the iron ring had ceased to be a magnet.



44.

The magnetism of the iron core had obviously acted on the coil B, and had inductively generated currents in it.

Induction by Steel Magnets. On the third day of the experiments Faraday varied the plan of experimenting as follows. He had seen that in the ring experiment the magnetism made by coil A was evidently the agent which acted on the coil B; and he tested the matter by changing the apparatus so as to use the magnetism of common magnets of steel instead of the coil A, which, with its part of the ring core, had acted as an electromagnet. Accordingly, he connected the galvanometer by wires to a new B-coil not wound on a ring, but wound on a short cylinder of soft iron; and magnetism was imparted to this core not by any magnetising coil, but by bringing into contact with its ends the poles of two bar magnets of steel. The arrangement is depicted in 45, where the poles are marked N and S. Every time that the magnetic contact at N or S was made or broken there was motion in the indicating galvanometer, showing the presence of transient induced currents in the coil. Hence, as Faraday records, here was a distinct evolution of electricity by the aid of magnetism.



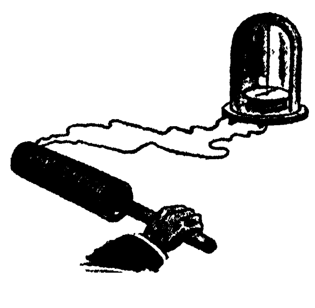
45.

Motion Essential. The circumstance that these effects were transient, and that no current, not even the feeblest, was generated while the magnets remained in contact, explained the failure of so many previous attempts. The missing factor in all the futile attempts had been *motion* or what was its equivalent, change in the magnetic state. The magnet *at rest*, or the electric current flowing with uniform intensity, produced *no inductive action* on the neighbouring copper wire. The magnet must move, or it induced no current. The current in coil A of the ring must equally not be a current at rest; it must be a current that is growing in strength, or a current that is in the act of dying, if it is to act inductively; for it is only while the current is changing its strength that the magnetism due to it undergoes change.

Movement of the Magnet. On the fifth day Faraday used a hollow cylindrical coil made by coiling 220 feet of wire around a pasteboard tube. This coil was joined up to the galvanometer. He then took a cylindrical bar magnet of steel 8½ in. long, and ¾ in. thick. On plunging it [46] into the coil the galvanometer needle made a quick movement to one side, and then returned to its zero. On pulling the magnet out, the needle again moved, but in the opposite direction. Here, evidently, an electromotive impulse was *induced* by mere approximation of the magnet, and not, as in the case of the iron ring, by formation of the magnetism in the stationary iron. Further, as the magnet used in the operation lost none

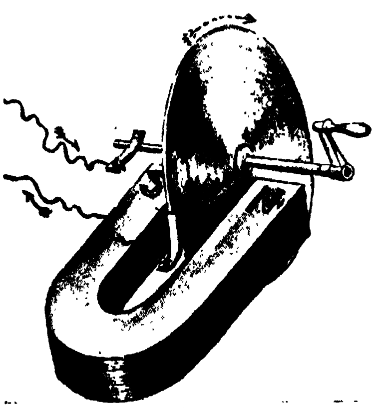
of its magnetism during use, the energy which propelled the current must have been derived from the movement of the arm. It was the *mechanical generation* of a current by the expenditure of energy rather than any conversion of magnetism into electricity.

Faraday followed up this experiment by another with two coils, each of which was separately stretched in the form of zigzags over wooden pegs against the face of a board. The A coil was joined to a battery, the B coil to a galvanometer. When the two boards were moved suddenly toward one another the needle was deflected ; when they were moved asunder the needle was deflected in the opposite direction. Soft iron electromagnets, when used in the same way as the permanent magnets, also produced inductive effects in a neighbouring coil. Faraday christened the phenomenon he had thus discovered by the name of *magneto-electric induction.*



46. FARADAY'S MAGNET EXPERIMENT

Faraday's Primitive Dynamo. On the ninth day of Faraday's experiments he was able to construct a "new electrical machine." Borrowing the most powerful compound magnet he could procure, he affixed to its poles, in order to concentrate its magnetism, two pole-pieces of iron, set about $\frac{1}{2}$ in. apart. Into this polar gap, where the magnetic field was strongest, he introduced a wheel or disc of copper, 12 in. in diameter and $\frac{1}{5}$ in. thick, fixed on a brass axis mounted in frames so that it could be revolved. Against the edge and axis of this revolving disc he pressed collectors of springy metal, and these he connected by wires to the galvanometer. Fig. 47 shows the apparatus. On revolving the disc by hand a current was continuously generated, which produced in the galvanometer a steady deflection. The direction of this deflection was reversed when the direction of rotation was reversed. "Here, therefore," he records, "was demonstrated the production of a permanent current of electricity by ordinary magnets."

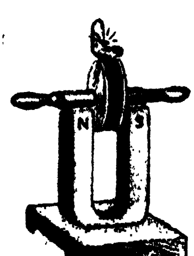


47. FARADAY'S DISC DYNAMO

This was the first primitive *dynamo.* The name, however, of *dynamo-electric machine* was not used till 1867, when Brooke coined this phrase to connote all machines of a similar character. "A dynamo-electric machine will be one in which dynamic energy is employed to produce an electric current."

Faraday further pointed out the important part in all these experiments and apparatus played by the invisible *magnetic lines* (p. 493) of the magnets. He showed that in order to create any of these inductive effects the copper conductors must so move as to cut across the magnetic lines, or else the magnets or magnetic lines must so move as to be "cut" by the copper conductors. In fact, the induced electromotive force is proportional to the number of magnetic lines cut per second.

Spark from a Magnet. In these splendid ten days Faraday had harvested a crop of new facts, new relations, and new principles, destined to immense development. He did not rest till he had shown that these induced currents could, like the currents from batteries, produce sparks and shocks. A simple piece of apparatus for generating a spark is depicted in 48. On the poles of a horse-shoe magnet rests a short bar of iron, provided with handles. Around the bar is wound a coil of wire, one of the ends of which is connected to a spring, making contact lightly against a metal button joined to the other end. On suddenly snatching this coil off the magnet a current is generated in the coil, and as the spring chatters at its contact with the mechanical shock, the current manifests its presence by a tiny spark.



48. FARADAY'S SPARK APPARATUS

Modern Commercial Development. Faraday, who devoted himself to pioneer research, did not push the commercial applications of his discoveries. "I have no time to make money," he explained. He ended this epoch-making research with the memorable words: "I have rather, however, been desirous of discovering new facts and new relations dependent on magneto-electric induction than of exalting the force of those already obtained, being assured that the latter would find their full development hereafter."

That "full development hereafter" we see in the thousands of dynamos and alternators, magneto-generators, motors and transformers which furnish light and power by electricity for the use of mankind all the world over. It was the self-denying genius of Faraday which made them possible. Faraday died a poor man, for he refused to patent his inventions, but gave them freely to the world.

SILVANUS P. THOMPSON

Division of Pulses. Rests. The Theory of Transition. Major and Minor Modes.

THE TONIC SOL-FA SYSTEM

Thus are the individual full pulses of the various measures marked out. We have next to consider how the pulses themselves are divided and extended. Here, again, the same simple means are adopted; for all time divisions and extensions whatsoever are indicated by just three symbols—the dot, the comma, and the dash. A pulse is divided into halves by placing a dot in the middle of it; into quarters by a comma in the middle of each half (for you must show the half division first); and into thirds ("triplets" is the Staff term) by two inverted commas. When a note is to be continued from one pulse into the next, the continuation is indicated by a horizontal line (or dash). A little illustration may be made to include all these time forms:

|d :m .s |d :r .m |f :s,f.m,f |s :l,s,f |s |-

The first measure introduces halves, the second measure quarters and thirds, and the last two measures show continued notes. Of course the continuation mark does not necessarily go always through a full pulse. Thus we may write:

|d :- .d |m : .r |s :- .f,m |r :d ||

where the continuation is for only a half-pulse. Similarly, a continuation may be carried into a third of a pulse, as here:

|d :— |-,s,f:m,r,m |s : - |-,f,r:d ||

There are, again, other forms of quarter division of the pulse besides the four notes of equal length. A pulse may, for example, contain a half-pulse note and two quarter notes, as here, where at *a* the half-pulse comes first, while at *b* the two quarters come first:

(*a*) (*b*)
|d .s :m .r,m |s .f :m,r.d ||

Another very common time division is shown in the following illustration, where we have a succession of pulses, each containing a three-quarter and a one-quarter note:

|d .,r :m .,f |s .,f:m .,r |m .,s:f .,r |d :— ||

This time-form is frequently met with in marches and other music of a bold and swinging character.

In advanced classical music many curious and minute subdivisions will be met with, the time notation of which—from what he has already learnt—the student will, as a rule, readily understand from the context. Special note should, however, be made of the way in which sixths, eighths, and ninths are written. The following illustration is taken from the authorised "Tonic Sol-fa Time Chart," which the earnest student of the notation should always keep beside him for reference.

Eighths	*Sixths* (*Three Accents*)
:l l ,l l .l l ,l l	:l l ,l l ,l l
Ninths	*Sixths* (*Two Accents*)
:l l l ,l l l ,l l l	:l l l .l l l

Rests in Tonic Sol-fa are not indicated by characters, as in the Staff. The pulse, or part of a pulse, is simply left empty; there is nothing in it to sing. Thus, at *a* there is a full pulse rest at the end of the measure; at *b* a similar rest at the beginning of the measure:

(*a*) (*b*)
|d .t_1 :d |r : | :d .t_1 |d .r :m |

Rests may be of any length, long or short. A half-pulse rest is indicated by a blank space on one or other side of the dividing dot. Thus, in the first half it will appear as

: .l |l .l : .l |l

in the second half as

|l .l :l . |l .l :l . ||

Quarter rests are just as readily indicated to the eye. For example, we see at once that here

: ,l .l ,l | ,l .l ,l

the first quarter is silent, while here

:l ,l .l , |l ,l .l ,

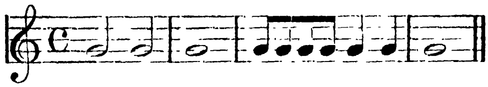
the silence is in the last quarter. Silent thirds may appear at first to be less clear. The following are the forms more generally met with:

First Third Silent	: ,l ,l
Second Third Silent	:l , ,l
Third Third Silent	:l ,l ,
Second and Third Thirds Silent	:l , ,

The whole matter of time-notation may seem, on first acquaintance, a little puzzling to the student. It is certainly much more original and novel than the notation of tune. But it is founded on a skilfully conceived and well thought out system, and the singer will soon discover that there is less difficulty in theoretically understanding the various subdivisions of the pulse than in giving practical effect to them by his voice.

One very important point has to be noted about the writing of Sol-fa time-notation It

was a point upon which Mr. Curwen laid great stress, and it is this, that each pulse in the same line of music must occupy exactly the same lateral space. Mr. Curwen would illustrate his meaning by showing how in the Staff notation this rule is disregarded, as, for example:



Here the measures and pulses fill very different spaces, according to the number of notes they contain. In Tonic Sol-fa they must be made equal, as thus:

|s :— |s :— |s :— . |— :— |

|s .s :s .s |s :s |s :— |— :— ||

The pulses, to quote Mr. Curwen once more, are "measured out, like the inches on a yard measure, and the eye rapidly values the length. An experienced Sol-faist keeps time by judging the distance between the notes, only stopping occasionally to look at the accent marks; and when through bad printing the pulses are unequal, he is completely put out." In writing Tonic Sol-fa, then, see that the accent marks are equidistant, and that, moreover, the medium accent and the weak accent are of a size with the notes. The strong accent should be at least double the length of the medium. Here is a bad but common specimen of Sol-fa manuscript:

|d . m / r . d .m| s . l |t. l . s |

Should be written:

|d :m |r :d .m |s :l |t .l :s |

Practically, the Tonic Sol-fa notation is a notation which gives visual expression to tune and time. It sets down the notes of the scale in its own peculiar way, and it indicates the lengths of the notes, also in its peculiar way. Beyond that, it may be said to correspond with the Staff. Its signs for *staccato* and *legato*, for example, are the same. Thus, when a note has to be struck in a short, disconnected manner, it is marked above with a dot. If the *staccato* is to be crisp—very pronounced—a dash is used: in both cases just as in the Staff. "Holds," again, are common to both notations. The sign 𝄐 is familiar. It means that the note is to be "held" or prolonged at the will of the performer. Thus, a three-pulse *Doh* with a hold over it might be made to occupy the time of five pulses. The hold is of the nature of a rhythmical licence. Repetitions, again, are indicated, as in the Staff. by the use of "Da Capo," or "D.C.," meaning "return to the beginning," etc. In everything that relates to the expression of the music, to its manner of rendering as regards force and intensity, soft and loud, fast and slow, etc., the two notations make use of common terms. It would thus be superfluous to repeat the information given under this head in the Staff notation papers, which the Tonic Sol-fa student may consult with profit to himself. He will find in the glossary, which appears later, a list of all the musical terms generally used for the direction of singer or player.

There is just one variation to be noted in this connection. In the Sol-fa notation the sign for the slur takes rather a different form from that used in the Staff. In the Staff, when two or more notes are to be sung to one syllable, a curved line is drawn over them. In Sol-fa, the plan is to draw a *straight* line *under*. So long as the line continues, only one word, or one syllable, as the case may be, is to be sung. Thus:

.s, d :d |d,r.m,f:s .d |r :r .m,f |m

When Bri - tain first at heav'n's com - mand.

In the Tonic Sol-f. no ation there are no signs of phrasing, as in the S aff.

When a change of key occurs there is never any doubt about it in the Sol-fa notation. Let it be premised that Sol-faists distinguish very sharply between transition and modulation. "Modulation," says the Staff theorist, "is the passing from one key to another." The term transition, he admits, "is also used, though principally to designate very brief modulations to keys not dwelt in." The Sol-faist, on the contrary, makes transition refer to all changes of key whatsoever, transient or of lengthened duration; while the term modulation he confines strictly to a change of *mode*—from major to minor, or *vice versa*. We will take transition first, the passing for the time being into a new key, where the old governing *Doh* gives up its place to a new *Doh* founded on a certain note of the old key. Before explaining how the notation expresses this, we had better clearly understand the nature of transition itself.

In a very short composition—a four-line hymn tune, for example—the composer may feel quite satisfied to remain in the one key throughout, though even in the shortest compositions transitions are often found. In a longer work the ear of the listener gladly welcomes, if it does not actually demand, a shifting of the *Doh* on to some other sound than that with which the piece began. In every instrument, as Mr. Curwen puts it, there is only a certain limited range of sounds at the composer's command, and he seeks to approach these from every point of view, to clothe them in every colour, and to make his changes as pleasantly striking as possible. Mr. Curwen insists that the pupil must be made, first of all, to *feel the need* of transition. This is easily possible by directing his attention to certain melodic factors of transition in which *Te* and *Fah*, the distinguishing notes of the scale, play the chief part. Look at this little bit of tune:

:d |m -.m |r :d f :f |m :r

:s :f |s :— |—

Does not the ear instinctively feel that something is wrong about the next last note? The ear wants the *Fah* to be a "leading note" to *Soh*—feels, in short, that the *Fah* ought to be raised a semitone, so that these two notes shall

sound like a new *Te Doh*. If we take it thus, then we have a simple transition where the *Soh* of the old key is turned into the *Doh* of the new key.

This is the commonest of all transitions. Next in frequency is the transition which makes the old *Fah* into the new *Doh*. The one is called the *first sharp remove*; the other, the *first flat remove*. The evolution of the process may be shown by taking our old Modulator for a centre, and writing a couple of little modulators by its side, the one having its *Doh* opposite the *Soh* of the centre modulator, the other having its *Doh* opposite the *Fah*.

d'	f'	
t	m'	l
l	r'	s
s	DOH'	f
	TE	m
f		
m	LAH	r
r	SOH	d
		t,
d	FAH	
t,	ME	l,
l,	RAY	s,
s,	DOH	f,
	t,	m,
f,		
m,	l,	r,
r,	s,	d,

Here we see at once an explanation of the terms "first sharp" and "first flat" remove. When the old *Soh* becomes the new *Doh*, the old *Fah* has to be sharpened (raised a "little step") in order to create a new *Te*. Similarly, when *Doh* is set against the old *Fah*, the old *Te* has be flattened (lowered "little step"), that th new *Fah* may come rightly into place.

So much for what may be called the theory of transition. We are now prepared for an explanation of how transition is written. It is an exceedingly simple matter. When the transition is very short indeed, the new tone is written as a Chromatic note—*fe*, *ta*, etc., as the case may be. Thus, the last six notes of the above illustration might be written:

:r   :s | :fe |s   :— |— ||

But even here, and at any rate in the case of all lengthened transitions, the "better method" is adopted of writing in the new key. The passing over into this new key is indicated by means of what is called, very appropriately, a "bridge-tone." A small note indicates the old key and the usual size of note the new. Thus, if the old *Soh* or the old *Fah* is to become the new *Doh*, the notation will show it in this way: ˢd   ᶠd

Our previous illustration would therefore be written as follows:

Key F.   Key C.t.
:d |m   .-.m |r   :d |f   :f |m   :ʳs |
|l   :d' |d'   :t |d'   :— |—

The indication "Key C" shows the new key which is entered, and the "t" following it points out the name of the new sound not in the old key which it is necessary to introduce. Similarly, if we pass from the key of F to that of B flat, as here:

Key F.   f.Key B♭.
:d |r   :m |f   :l |s   :— |—   :ᵈ's |
|f   :m |r   :d |t,   :— |— ||

the "f" at the left side of the new key-name shows that *Fah* is the sound that was not in the old key. This pointing out of the new tone is entirely for the guidance of the singer's ear. And, indeed, in the letter notation, it is the singer's convenience that is consulted first. Thus, at the return to the former key, the bridge-tone is always placed at the point where it can most readily assist the singer, whether that corresponds with the actual theoretical change or not.

It is hardly necessary to say that transition is not always made to a key of one "remove" from the prevailing key. This fact the student can bring home to himself by constructing a modulator, not with one other modulator on each side, but with six or seven modulators on each side, each modulator in its turn taking the previous modulator's *Soh* or *Fah* and placing a *Doh* opposite it. Thus, having set down one modulator on the right side of the centre modulator by placing its *Doh* opposite the old *Soh*, he can deal similarly with the second modulator by placing a *Fah* opposite its *Doh*, and so creating a third modulator. A like process can be adopted for the left side. Each new modulator will represent a new key with a new tone not found in the modulator that preceded it. Well, we often come upon transitions in which the intermediate keys (modulators, let us say) are skipped over, so that the new key may require, not one, but three or four new scale-notes. A single example of this will suffice:

Key C.   s.d.f. Key E♭.
|d' :—|t   .d'|d' :—|—   :ᵈ'l |t   :—|d' etc.

Here is a transition which passes over two keys. The original key, observe, is C. Thus, to reach E flat, we have to skip altogether the intermediate keys of F and B flat. More distant "removes" are much used in modern music, where the tonality has often a tendency to continual shifting.

Now we are in a position to take up the subject of modulation. Most people who know anything at all about music know that there is some distinction between the so-called major and minor modes. Briefly, a "mode" arises from the prominent use of one particular note in a composition. Thus, if a piece begins and ends with *Doh*, and all through has *Doh* as a sort of central pivot, it is said to be in the Major Mode. If, on the other hand, it takes *Lah* for its dominating note, it is said to be in the Minor Mode. The distinctive terms Major and Minor are derived in each case from the

third above the dominating factor. The third above *Doh* (*me*) is Major, hence the mode which recognises *Doh* as its "governor" is a Major Mode. In the same way, the *Lah* mode is a Minor Mode, because the third above *Lah* (*doh*) is a minor third.

Formerly, they used to have modes founded on every note of the scale: national folk-songs still survive in the *Ray* and *Soh* modes. But in modern music only two modes—the Major Mode of *Doh* and the Minor Mode of *Lah*—are recognised. The old minor mode of *Lah* was simply the unaltered scale founded on that note:

l_1 t_1 d r m f s l

Thus, we have the Scottish air "John Anderson, my Jo" ending in this way:

:l_1 | m_1 :l_1 l_1 :s_1 | l_1 :— ||

But the modern *Lah* mode is different. It is partly a concession to the exigencies of harmony, partly a concession to the modern ear, which had got so accustomed to the prevailing major mode, with its half-tone (*te*) below the key-note, that it did not take kindly to a mode with a whole tone (*soh*) below its key-note. Hence, the *soh* was sharpened so as to make it a semitonic leading-note to *Lah*. The result was:

l_1 t_1 d r m f se l

the *se* taking the place of the old *soh*. But here a new difficulty presented itself. The leap from *Fah* to *Se*—a tone and a half—is by no means an agreeable progression; and so the *Fah* is often raised to make a smoother melodic interval. What shall we call this sharpened *Fah?* It will not do to call it *fe*, for *fe* suggests the first sharp key. So, in Sol-fa it is called *ba* (pronounced *bay*), and to save space is occasionally contracted to *b*. It is a note artificially introduced, remember, having no existence except in connection with *Se* in the minor mode. The final result, then, is this:

l_1 t_1 d r m ba se l

There are thus three forms of the minor scale; two of them diatonic (moving by tones and half-tones), but differing as to the place of the semitones; the third chromatic—that is, introducing chromatic intervals and containing three semitones.

The Sol-faist takes a very different view of the minor mode from the Staff notationist. The latter regards the minor mode as an independent, though "relative," scale; the Sol-faist, on the contrary, regards it as merely another form of the major scale—a "mode" of using the scale of *Doh*. Thus, while the Staff notationist speaks of the separate keys of C major and A minor, the Sol-faist looks upon them as practically one key; A minor, in his view, being merely a "mode" of C major. Hence, in giving the pitch-note of the key, the Sol-faist always places *Doh* first; so that when the Staff notationist says "A minor," the Sol-faist says "Key C, *Lah* is A." In short, the Sol-faist gives the pitch of both *Doh* and *Lah*. To a beginner, the whole subject of the minor scale or mode presents very considerable difficulties; in Sol-fa the difficulties are perhaps rather less than in the Staff. In either case they are theoretical rather than practical.

Mention has been made of "chromatics." These are practically the equivalents of the accidental sharps and flats of the Staff. Composers, says Mr. Curwen, often use an effect which is derived from the pleasure that the ear takes in transition. They introduce a *fe* or *ta*, or some other note which leads us to expect a transition, and instead of changing the key, they contradict their intention and remain in the original key. If *fe* is the new tone in a "sharp" transition, it is manifest that if *fah* follows it immediately the old key is reaffirmed, and *fe* blotted out. So when *ta* is the distinguishing note, if we pass on to *te* we reassert the old key. This treatment is called "chromatic," to distinguish it from "transitional," though it must be observed that there are chromatics which do not necessarily even suggest a change of key.

In the Sol-fa notation the names for the sharpened and flattened notes of the scale are shown here, first in ascending, and then in descending:

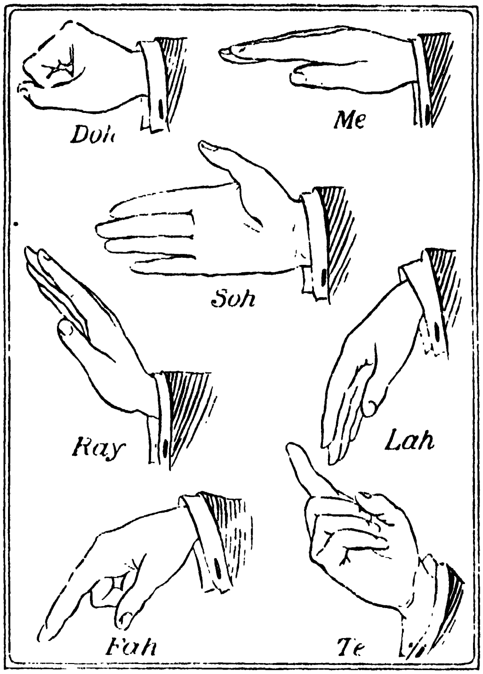
d de r re m f fe s se l le t d'

d' t ta l la s fe f m ma r ra d

It is necessary, of course, to write these chromatic notes in full, so as to distinguish them from the corresponding diatonic note.

Thus far we have dealt with Tonic Sol-fa chiefly as a notation. But it is much more than that. Sol-fa has a *method of teaching* which is, in several respects, peculiar to itself. For instance, great stress is laid on the mental or emotional effects of the individual notes of the scale. *Doh* is recognised as firm and bold; *Soh* as bright and trumpet-like; *Me* as calm and restful; *Lah* as sorrowful and wailing; *Fah* as desolate and awe-inspiring; *Ray* as rousing; and *Te* as shrill and piercing. Great pains are taken by Sol-fa instructors to impress these emotional effects on the minds of pupils, and practical experiment is every day proving that their recognition is a very great help to the correct singing of the notes. Of course, the effects described apply strictly only when the notes of the scale are sung or played slowly. A quickly moving rhythm and certain forms of accompanying harmony may each greatly modify the individual effects. Thus, the minor mode, which sounds sad and solemn in a measured movement, may be made to sound quaint and jovial when sung rapidly.

Out of these mental effects may be said to arise another special feature of Sol-fa teaching—namely, the use of manual signs for the various notes of the scale. Thus, every manual sign endeavours to suggest the emotional characteristic of the tone for which it stands. The clenched fist typifies the firmness of *Doh*; the restfulness of *Me* is indicated by the flat palm; the rousing character of *Ray* by the raised



MANUAL SIGNS

palm; and so on. These signs, which we here reproduce by permission of Messrs. Curwen & Sons, are much used in popular classes, either when the teacher desires to remind his pupils of the mental effects just described, or in voice exercises, when it is desirable that the singer's attention should not be distracted by having to look at book or modulator. A system of manual time-signs is much less used.

A third feature of Sol-fa teaching is the separate study of tune and time. Tune is taught first from the modulator, and then time is taught by itself, largely by means of a set of "time-names," the improved invention of a Frenchman, M. Aimé Paris. It would occupy a great deal of space to give a complete list of these time-names, with the corresponding notation. The following illustration introduces the rhythmical forms most frequently met with:

d :m	s :—	s .m :l .d'	s :—
Taa Taa	Taa - aa	Ta Tai Taa Tai	Taa - aa
m :- .f	r :d,t₁.d,r	m :	
Taa - aa tai	Taa ta fa te fe	Taa Saa	
s :m	d',s.m :d ,m.s	d :—	
Taa Taa	Ta fa Tai ta fa Tai	Taa - aa.	

In applying these names to his early exercises, the Sol-fa pupil sings them *on one tone* till he has mastered the time, and only then does he try to combine the time with the tune. The value of the method for beginners is obvious. It gives them a confidence which they could not possibly acquire so soon in any other way.

Much more might be said about the Sol-fa method of teaching if one had "ample room and verge enough." Mr. Curwen has admirably summed it up in a few words: "To let the easy come before the difficult; to introduce the real and concrete before the ideal or abstract; to teach the elemental before the compound, and do one thing at a time; to introduce, both for explanation and practice, the common before the uncommon; to teach the thing before the sign, and when the thing is apprehended attach to it a distinct sign; to let each step, as far as possible, rise out of that which goes before, and lead up to that which comes after; and lastly, to call in the understanding to assist the skill at every step." These principles find their most exhaustive explanation in "The Teacher's Manual of the Tonic Sol-fa Method."

In studying *harmony* [see THEORY OF MUSIC] the Sol-faist uses a chord-naming notation of his own. In the Staff the chords are indicated by a system of figured basses. In Sol-fa the nomenclature corresponds in simplicity with the notation of tun Each chord of the scale is named by its Sol-fa initial letter, printed as a capital, as here:

m	r	d	r	m	
s	t	l	l	l	
d	s	f	f	d	
d	s	f	r	l	
D	**S**	**F**	**R**	**L**	etc.

In the minor mode the chord capitals printed in italics. Chords in their direct form that is, with the root in the bass, are said to be in the *a* position, but in the nomenclature the *a* is always omitted. The further positions (inversions) are indicated by the letters *b*, *c*, *d*, etc., as the case may be Thus

a	m	s	r	
s	s	r	t	
d	d	s	s	
m	s	t	r	
Db	*Dc*	*Sl*	*Sc*	etc.

The minor dominant chord—m, se, m, t—is known as ^{se}**M**. When a seventh, a ninth, or a fourth is added to a chord (remember that a common chord consists of root, third and fifth), the fact is indicated by a little figure at the upper left-hand side of the chord-name:

^7S ^4S ^9S etc.

Passing notes, again, are indicated by an italic *p* printed under the chord-name—*p* only when the passing note is dissonant, *cp* when consonant.

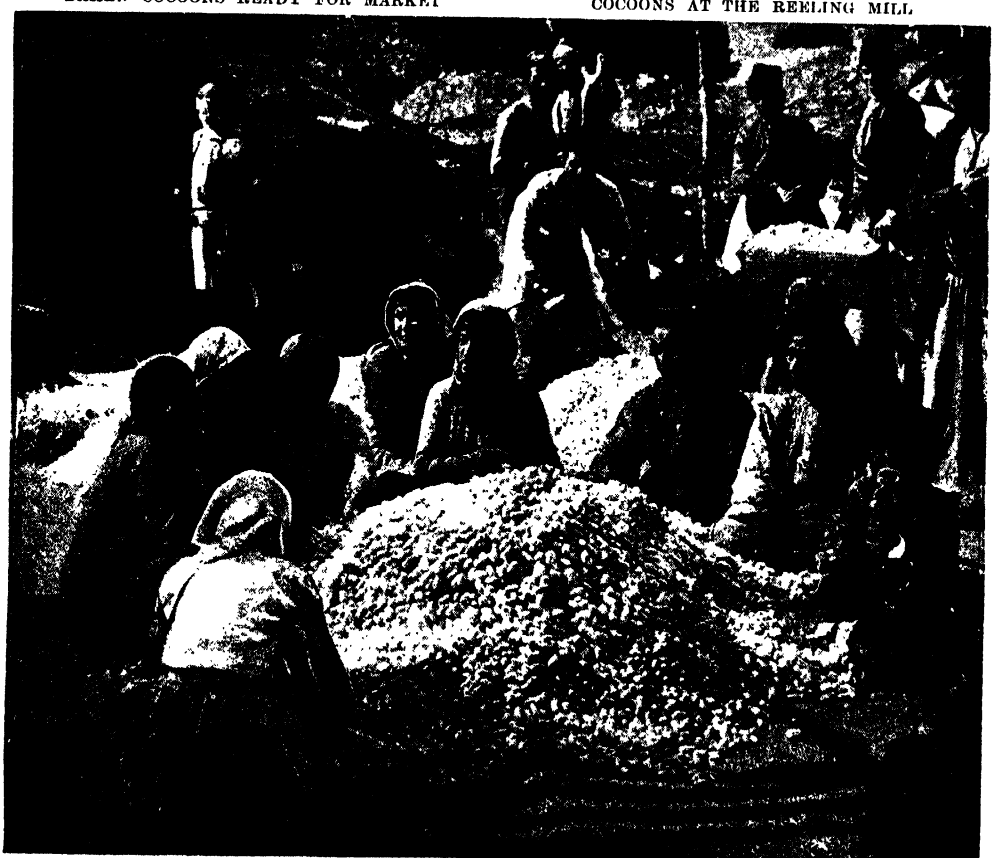
Such are the general principles of the Sol-fa notation and method of teaching. For minute details it is necessary to consult the published manuals and treatises of the Tonic Sol-fa Press, in particular "The Standard Course of Lessons and Exercises in the Tonic Sol-fa Method of Teaching Music." The Staff notation musician who desires to study the notation in comparison with and from the special point of view of his own notation should see "Tonic Sol-fa," by John Curwen, in Novello's "Music Primers" series.

A valuable series of technical dictionaries, explaining special terms and phrases, appears at the end of the Self-Educator.

THE BEAUTIFUL COCOONS OF THE SILKWORM

BAKED COCOONS READY FOR MARKET

COCOONS AT THE REELING MILL



TURKISH WOMEN SORTING COCOONS AT A SILK MANUFACTORY

The Rearing of Silkworms. The Crop. Adulteration. Artificial Silk from Wood Pulp.

SILK—THE QUEEN OF FIBRES

SILK retains its title of the queen of fibres, but it is much less exclusively an article of luxury than was formerly the case. In the Western world its principal use is in making mixed fabrics saleable to a large public at a moderate price. Under the conditions of life in the East silk is rather a necessary than a luxury, and silk, therefore, is still distinctively an Oriental product.

Four-fifths of the commercial crop of raw silk is shipped from the Far East and Levant. This statement takes no account of the very large native consumption in Asia or of the manufactured silks such as reach Europe from Japan. The Western manufacturing world, represented by the countries of Europe and North America, absorbs currently a commercial crop of about 25,000 tons of raw silk, of which about 11,000 come from Japan, 7000 from China, 4000 from Italy, and 2300 from the eastern end of the Mediterranean.

Raw Silk. It is necessary to be clear as to the meaning of the words *raw silk*, or *raws*, as the article is often called. On the analogy of raw cotton or wool the term might be supposed to indicate the cocoons; but, as a fact, it implies silk *reeled* or unwound from the cocoons and put into a form suitable for further working. The work is done to a small extent and in rather a rough fashion in small reeling establishments in the East, but is more generally and much better effected in the large, steam-heated *filatures* or factories.

The Cultivation of Silk. The natural processes by which silk is secreted by an insect are widely known, but an outline of them will clear up some matters of moment in connection with the manufacture. For its cultivated silk the world is indebted chiefly to worms of the order of *Bombycidæ*, of which there are some hundreds of species. The *Bombyx mori* is the typical one, and its culture begins with the collection of eggs from selected moths that have been allowed to develop to maturity and breed.

These eggs are so small that a single ounce of them will produce about 35,000 worms, and so well encased that they can be kept at low temperature for an indefinitely long time, to be incubated by heat when the natural food of the silkworm is ready for consumption. This food is the mulberry leaf, of which vast weights are consumed by silk growers. The eggs are placed upon trays in specially constructed, airy, and warmed apartments, and are covered with paper sheets perforated with small holes. The worms hatch out in a few days, and the larvæ, in squirming through the holes in the paper in their struggle to reach the light, free themselves of the remnants of shell or egg-casing. They begin at once to feed upon the tender leaves provided for them, and continue to eat ravenously for the three or four weeks of their larval stage of existence. The process of feeding and growing is interrupted by periodical moultings, during which the worms are especially susceptible to outside influences such as noises. Having attained maturity, they enter upon the chrysalis form; or, in other words, begin to produce silk. Attaching themselves to twigs, or inserting themselves between two or three leaves, they wreathe their web around their own bodies.

The Worm and its Products. The worms are provided with glands extending along each side of the body, and discharging their secretion from a single orifice, the *spinneret*, upon the under lip of the worm. The fluid formed in these sacs solidifies in contact with air, and the separate formation of each stream or *brin*, united by passing through one jet into a single filament or *bave*, can be seen upon raw silk through a powerful microscope. The brins are coated outside with *sericin*, a compound soluble in water, which in commerce is spoken of as *gum*. The insoluble part, or *silk*, is known to science as *fibroin*. A coarse silk is deposited on the outside of the cocoon, and a very fine and frail silk, too tender to be reeled off, upon the inside of the cocoon.

The reelable silk is limited to the intermediate layers, and one cocoon provides from 500 to 1300 yards of this material. The outer layers, with their adherent sticks and leaves, are stripped and sold as *blaze* or *wadding*. The clean but coarse husk, or *knub*, unsuitable for continuous reeling, but still capable of being spun in a similar manner to wool, flax, or cotton, is put aside and sold as *waste*, as is the silk that is broken or tangled in the reeling process

The quantities of raw silk and of waste produced are about equal, and, on the average, less than ten per cent. of each form of silk is produced from a given weight of fresh cocoons. Left to themselves in a favourable temperature, the pupæ bore their way out of the cocoons and emerge as winged and gaily coloured moths. Only those worms selected for breeding are allowed to survive, because *pierced cocoons* are useless to the silk reeler. The worms inside cocoons intended for the market are put to death by steaming or baking.

The Influence of Leaf Food. The operation of rearing worms is not a lengthy one, for the worm begins to spin in one month from the date of hatching, and the cocoons are completed in three or four days. It requires, however, attentive supervision and a large amount of labour. The 30,000 worms that come to maturity from one ounce of *graine*, or seed,

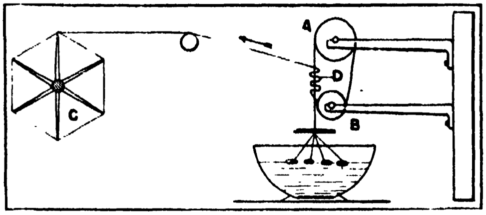
need about one ton of ripe leaves to sustain them in their larval stage, and these leaves have to be gathered and examined to see that they are clean, dry and wholesome. The yield from all this provender is about 12 lb. of raw silk, and a similar amount of valuable silk waste. The cultivated worms fed upon mulberry produce the white and yellow silks of commerce. There are also the wild varieties, feeding chiefly upon oak leaves, and producing the brown or *tussah* silks. The produce of a number of different varieties of worms is known by this name, and, in general, their silk is coarser and harsher than that of the cutivated type. As tussah fetches lower prices in the market, the deliberate culture of these worms does not pay. Experience in attempting to rear silkworms in England and America has shown that commercial success can only be reached where labour is cheap, and for this reason, rather than from climatic causes, Asia and Italy are left to provide the main supply.

The Treatment of the Cocoon. The *bave*, or individual filament of cocoon silk, is too delicate for unsupported use, therefore the raw silk of commerce is made by combining a certain number of these filaments together as one thread. In the first place, the gum which binds the silk in a compact mass has to be softened, and in the best filatures this is done in the boiling machine. The cocoons, packed in perforated boxes, are immersed in water which is kept at a high temperature by steam. They are transferred then in a loose state to the beating machine, and are pressed upon by mechanical brushes which remove the outer husks. When the machine is stopped the brushes rise, and the operative finds the end of reelable silk clinging to the bristles. As many cocoons as are needed to make the thickness of raw silk required are put into the basin of the reeling machine, in which they float. The number of cocoons taked may be as few as four or as many as twenty.

Silk Sizes. The silk is made to *deniers*, a count or measure of fineness of French origin recognised throughout the silk trade. The denier is an old standard of weight (=·0531 grammes), and the number of deniers contained in a length of 400 *aunes* (= 476 metres) denominates the fineness of French raw silk. The denier standard varies slightly in different countries, and the *international denier* is based on the number of $\frac{1}{20}$ grammes weighed by skeins of 450 metres. The *dram* measure is more freely used in English practice, and the dram count equals the number of drams weighed by a hank of 1000 yards.

Forming the Skein. The threads drawn from the floating and softened cocoons are brought together by being passed through an eyelet above the basin of the reeling machine, and the combined threads are led through a more or less complicated series of eyelets before being wound upon the *swifts* or arms of the hexagonal reel, where a skein is formed. In the best filatures the path of the thread through glass eyelets and over round rods is a very intricate one, and in course of its passage the thread is led back and around itself. The silk thus receives a great deal of smoothing and rounding, and its constituents are well bound together and freed by friction from many irregularities before the thread is formed into the skein.

In more primitive systems the cocoons are softened by being hand-beaten with twigs instead



A DIAGRAM OF SILK-REELING

of by mechanical brushes; and in reeling the silk describes a less roundabout path to its goal. In the simple type of apparatus illustrated the ends of silk from the several cocoons pass through a ring or opening in a metal plate, and over a wheel (A), under a wheel (B), and on to a reel (C). At the point (D) the thread is crossed a few times around itself to mould the filaments well together, and remove surface defects.

Silk reeled in this or in a more primitive manner in China is given the name of *Tsatlee.* There are different qualities of Tsatlees, but all this silk is troublesome to work.

Re-reeled Silk. This once-reeled raw silk is often re-wound from one reel to another, and in transit from one to the other it is passed through a series of cleft wooden guides. These catch projecting irregularies upon the yarn, and when the faulty places have been removed and the whole has been re-wound, the silk is spoken of as *re-reeled.* Most silk is now *re-reeled*, or is produced in filatures upon machinery.

We have already seen that in different parts of the cocoon the bave varies in thickness, and it will be understood there is a material difference between threads composed of six strands all from the outer portion and six ends all from the inner portion. Such a thread is thicker in some parts than in others. What is wanted is as smooth and equal a thread as possible, for a rough, unequal one either injures the appearance of the finished goods or sets up delays and trouble in the subsequent processes by which the raw silk is brought into fit condition for weaving. Silk *throwsters*, who manufacture *organzine* or warp and *tram* or weft, out of the raw silk obtained from the reeler, can deal with 20 or 30 lb. of high-class Italian filature raws in the time it takes to deal with 10 lb. of Tsatlees.

Silk manufacturers import a considerable part of their *net* silk or *neat* silk in the thrown state, but of such as is bought raw about three-fourths is from China, from whence the whitest and brightest silk is procured. The words net or neat are used in contradistinction to *waste* or *spun* silk—net silk being that which is reeled

continuously, and spun silk that which is spun from the waste fibres.

Descriptions of Silk. In the silk trade a specially limited meaning is implied by the word *China*. China silk means silk from the North, shipped from Shanghai. The Southern Chinese silks are always called *Cantons*, after the port of shipment, and they are generally less white in colour than the silks of the North. The yellow Seychuen silks and the coarse Hangchow and Kahing silks are shipped from Shanghai, and so are the brown *tussahs*, to which reference has been already made. These, however, are distinct articles, separate from the pure white *Chinas*, for which the North is world-famous. The skeins of China silk formed upon the reels are spoken of as *slips*, and several of these skeins laid together form a *moss*. Twelve mosses folded over in book form constitute a *book*, and there are twelve such books in the regular China *bale* (100-104 lb.) of raw silk.

Japanese raw silk, although it is a larger item than Chinese in the world's silk supply, is comparatively little used in England, most of it going to the United States. Only about seven and a half per cent. of the raw silk imported into this country comes from Japan. The Japan silks are all re-reeled or filature-made, and they are of a greyer cast of colour than Chinas. They also are graded by number, and under private trade marks.

East Indian silk was at one time the material principally used in this country, and was obtainable under a lower rate of import duty than foreign silk. The consumption is now much smaller even than that of Japan silk, and its use is confined to a few special purposes. The chief variety is *Bengals*, shipped from Calcutta. The bulk of the silk is of a strong yellow colour, which, however, disappears in boiling, and a smaller proportion of the cocoons are white. Three crops of Bengal silk are obtained in a year, and the raw silk is sold as March, July or November *bund*, according to the season of growth.

European Silk. European silk ranks next to Chinese in English use, largely because of the intelligence that has been bestowed upon the rearing and handling. The cocoons are produced in a more cleanly manner than the Chinese, and the filatures are well appointed with modern machinery. A large part of the European silk imported into England comes from France, where there are about 100,000 registered silk growers in receipt of bounty from the Government upon the cocoons harvested. They raise from 10,000,000 to 18,000,000 lb. of cocoons, and the 200 odd French reeling mills produce from these 700,000 to 1,400,000 lb. of raw silk. The produce is marketed at Lyons, and is raised in the neighbouring country from the Pyrenees to the Cevennes.

Milan is now the chief European raw silk market, and Lombardy, Venetia and Piedmont the three chief sources of Italian silk. There are nearly 700 reeling mills in Italy producing silk generally rich in lustre and yellowish in tone. Their silk fetches higher prices than the Far Eastern raws, and it is graded into four classes, respectively defined as *extra classical, classical, sublime,* and *common.*

The silks from the Balkan countries, Persia and Asia Minor, play a very small part in British industry, and of the Levant silks the best known are *Brussas* (Asia Minor).

Silk Waste. All silk reeling involves the production of silk waste; the spinning of this material into yarn is a much larger business than silk throwing in this country, and it employs some 10,000 hands. Legend has it that the utilisation of silk waste rested undiscovered until 1857, but it is certain that waste has been spun in English factories for 150 years, and silk waste has been imported for at least three centuries.

The spinner buys the waste proceeding from the basins of the reeling mill, and this, along with that formed in reeling and re-reeling, constitutes the main supply. Use is made also of the so-called *gum-wastes*, the by-product of silk throwing, but this material is comparatively scarce. Of late years the main source of supply to British spinners has been the filatures of Northern China, whose waste is called *steam waste*, and is sold either as *unopened* or *opened* according as it has or has not been put through a process to tear the gummy mass into a looser condition. Some kindred wastes from the same country are *frisons*, or cocoons which have been roughly opened without being reeled; *curlies*, a matted sort of silk waste; *punjum books*, the most lustrous of wastes and called books because the waste is folded over in the same manner as Chinese raw silk. The cocoons pierced by the breeding moth are reserved for silk spinners, but are not largely used in England.

The most important of the special wastes is the wild *tussah*, extensively used for making plush goods, and it has more than once happened that tussah waste has fetched higher prices than tussah raws. Although called waste, much of the material fetches two or three shillings a pound. The wastes are collected with care in China and are brought to the ports, where they are bought and closely inspected by the silk inspectors of the large merchant firms.

Japan is the largest waste-producing country, and increasing quantities from this source are being used by the English spinners. The *Kikai Kibizzos* from the large filatures are the best esteemed Japanese material. Waste is bought from other countries at prices varying with the strength, lustre, colour, and cleanliness of the material, and preference is given to such parcels as are free from cotton and from hairs. As it is employed to make yarns which often cost over ten shillings a pound, the desirability of avoiding faulty material is obvious.

The Treatment of Waste. Waste is used in England to make yarns from which the natural sericin or gum is removed by boiling; such yarns are spoken of as *fully discharged.* Upon the Continent the waste is not boiled, but subjected to a process of fermentation to loosen the gum, which is then removed in part by a more

or less prolonged washing. These yarns are called *schappe*, and they serve some purposes distinct from those for which the clean, strong and lustrous English yarns are taken. Schappe yarns contain gum in proportions varying from a nominal quantity up to about twenty per cent. They are darker in colour and are often made with silk of shorter fibre than English. Some of them are cheap and, owing to the presence of a proportion of gum, the yarn can be spun to high numbers with little irregularity.

In putting waste silk through the processes which convert it into yarn a certain amount of short-fibred silk or *noil* is rejected. These noils can be re-combed when the length of their staple makes the process worth while, and the longer fibres thus recovered are made into cheaper classes of spun yarn. The short-fibred silk left over from combing is known as *exhaust noil* and is used sometimes by woollen spinners to create special effects in tweeds. The noils are also spun by noil spinners to make coarse silk cloths for wiping machinery and bags for carrying ammunition. These articles, when worn out, can be shredded and used to make coarse cloths again.

Artificial Silk. The product known as artificial silk is not silk at all. Its chemical nature is quite different, and whereas real silk is the strongest of fibres, the artificial silks are the weakest in present textile use. Three kinds of artificial silk are in use—the *nitro-cellulose* or *Chardonnet* silk, made by dissolving waste cotton; the *cupro-ammonium* silk, also made from a base of cotton; and the *viscose* silk, made from wood pulp. All three have a supernaturally bright lustre, and the first two have their use principally in making trimmings and articles not subject to friction in wear. Viscose silk is both the cheapest to produce and the one which best resists the rough treatment received in weaving and finishing cloth.

Artificial silks are made by squirting solutions through fine jets and immediately solidifying these streams of jelly. The filaments thus formed are combined with others to make a serviceable thread, much as the threads from various cocoons are combined into one in reeling raw silk. Probably 6000 tons a year of this material—or about one quarter of the quantity of raw silk employed in the Western manufacturing countries—are now being used in textile industry. In manufacturing artificial silk yarn a quantity of waste is made, and uses have been found also for this. The broken yarn is fed into an opening machine, which teases out the individual filaments, and when spun along with wool this waste creates novel effects in fancy goods.

Demerits of Artificial Silk. The successful prosecution of several traders for selling artificial silk goods as "silk," "art silk," "Colonial silk," and other names suggestive of the natural article, helps to emphasise the differences between silk and the chemical substitutes to which its name has been applied. The large consumption of artificial silk that has sprung up in the last ten years does not necessarily prejudice the sale of the genuine article, for the merits of the two are distinct. The chemical silk has a high lustre, but this feature is contingent upon having the yarn very loosely twisted, a condition which is not at all favourable to good wear.

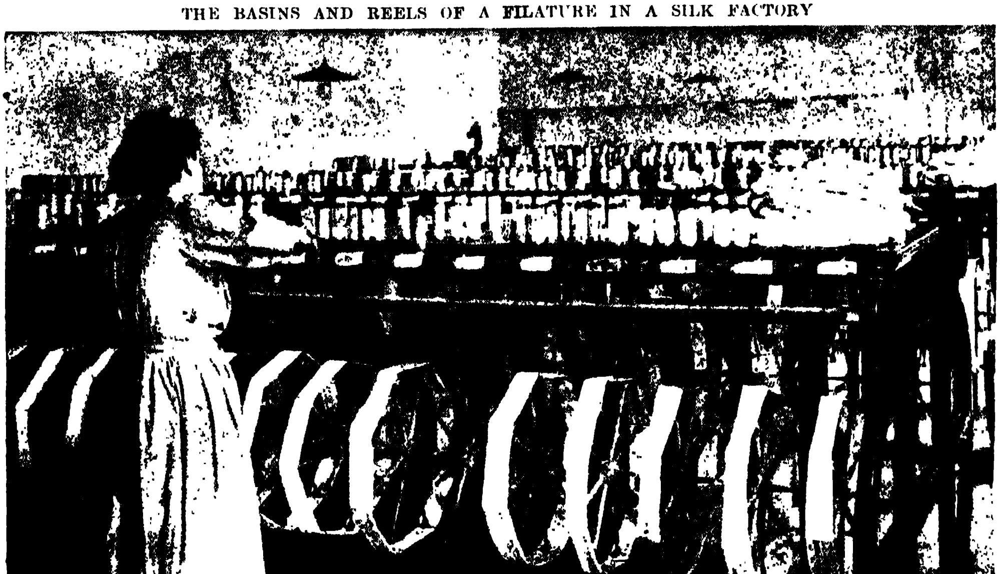
Pure silk is little affected by wetting, but water destroys almost the whole strength of the artificial article. Pure silk dyes evenly to all shades and the colour stands fast, but artificial silk is generally uneven in colour if dyed. Artificial silks are made that will bear washing, but when washed the colours *bleed*, and white artificial silk knitted—for example—along with wool into stockings is discoloured in washing by the dye of the surrounding wool. The material will probably be improved as time passes, but the gulf between real silk and cellulose is one that can hardly ever be bridged.

"Weighting" Silk. The good name of silk has been itself prejudiced by practices much more common upon the Continent than in this country. Real silks have been heavily *weighted* in course of dyeing, with the consequence that the articles give dissatisfaction in wear. In dyeing any silk from which the gum has not been discharged there is a loss of weight due to the removal of sericin.

For some centuries past means have been taken to restore this loss by precipitating metallic salts upon the fibre in the course of dyeing, and there are limits within which the practice is not seriously objectionable. Some manufacturers, however, have advanced far beyond the mere restoration of loss. It is possible by the free use of tanning compounds and salts of iron and tin to make one pound of pure silk weigh three or four pounds in the dyed condition. Of a fabric so composed only a small minority is silk, and the deceit betrays itself in wear. The garment *cuts* as soon as it is worn, or in bad cases falls into ruin even without being worn; true silk thereby suffers an undeserved discredit.

The Protection of Silk. As with any other textile, the amount of satisfaction to be derived from silk is a question of how the fabric is manufactured as well as of what material. Measures have been proposed by the Silk Association for enforcing standards of purity in any goods sold under the name of silk with the view of letting purchasers know to what extent any particular sample is sophisticated. The fibre has naturally qualities which have earned it an excellent name, and this reputation is worth guarding. There are in India coats made of *Eri* silk, the produce of a worm feeding upon the castor-oil plant, which have been worn by three generations of native families without being much the worse for wear. It has already been said that in the Western world there is a consumption of silk, large in the aggregate, outside the regular silk industry. Much material goes to make articles not sold specifically as silks. Doubtless some silks are bought with no particular expectation of wear; but, on the other hand, there is sound assurance that deceits have provoked dissatisfaction hurtful to the interests of the silk industry. J. A. HUNTER

THE BASINS AND REELS OF A FILATURE IN A SILK FACTORY



WINDING SILK IN THE THROWING MILL

THE SUN SEEN FROM ITS NEAREST PLANETS

Mercury. From a study of the surface of Mercury the evidence seems to show that conditions and features are similar to those on the moon, only more pronounced—very little atmosphere, dark, rugged surface, beds of extinct molten seas of lava, and great craters and mountains, the whole parched and cracked and composed of dark, rugged surface akin to basalt and lava. The stars would be visible in daylight, notwithstanding the enormous apparent size of the sun, owing to the rarefied atmosphere. Water may be present in parts of the planet

Venus. Venus is generally regarded by astronomers as possessing a very dense and cloud-laden atmosphere, very high mountains (27 miles high), and, according to Flammarion, conditions otherwise approximating to those of our earth.

IN THIS SCENE ON THE EARTH THE SUN IS SHOWN ON THE SAME SCALE AS IN THE PICTURES OF MERCURY AND VENUS

The Motions of Mercury and Venus inside the Earth's Orbit round the Sun. How the Earth is Weighed.

MERCURY, VENUS, AND THE EARTH

There are two known planets which move round the sun in orbits smaller than that of the earth, and as this leads to certain peculiarities in their appearance, which distinguish them from the other planets to human eyes, we may deal with them before passing on to the earth. These two, of course, are Mercury and Venus. More than once the discovery of a planet still nearer to the sun than Mercury has been announced, and this supposed planet has even been christened Vulcan, but it is almost certain that the alleged observations of it are misleading. There might, indeed, be a planet nearer to the sun than Mercury without our being sure of its existence, as its light would almost always be drowned in the solar radiance. Certain peculiarities in the movements of Mercury have been attributed to perturbations caused by the attraction of an inner planet, but the careful search made for this planet during eclipses of the sun has hitherto proved unsuccessful.

Mercury. Mercury, the inmost of the known planets, moves round the sun at a mean distance of about 36,000,000 miles. It is the smallest of the major planets, being only 3030 miles in diameter, or a little more than one-third the size of the earth. The plane of Mercury's orbit is inclined at an angle of 7° to the ecliptic, which is more than the inclination of any other planetary orbit. The Zodiac had to be made 16° wide in order to include the apparent movements of Mercury.

The year of Mercury, or the time in which it completes its revolution round the sun, is equal to 88 of our days. Mercury certainly rotates on its axis, but it has been extremely difficult to determine the period of this rotation, owing to the lack of definite markings on the planet's surface, which, as it is seen by us, probably consists of a mass of clouds. The latest conclusion is that Mercury rotates on its axis in the same time as it completes a revolution in its orbit—88 days. In other words, its day is equal to its year, and it always presents the same face to the sun, just as—and probably for the same reason—the moon always presents the same face to the earth.

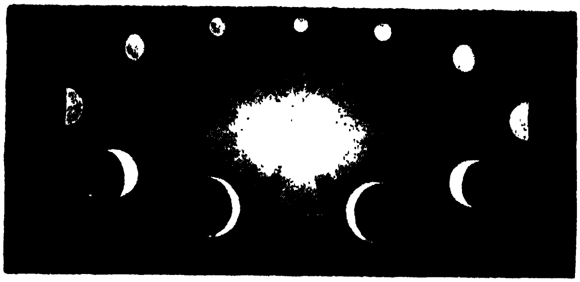
A Planet Where Life is Impossible. As will be shown when we come to study the case of the moon, there are reasons for supposing that this will be the ultimate condition of all the planets, including our own—namely, that their period of rotation and of revoluton round the sun will become the same. At that very distant date the dwellers on the earth, if they be not extinct, will find their planet divided into two nearly equal zones, one of which enjoys perpetual day while the other is sunk in everlasting night. The sun, instead of moving regularly round the earth, will only vibrate backward and forward in the sky for a comparatively short distance. All life will necessarily congregate on the side of the earth which faces the sun, because the opposite side will be chilled down to a temperature nearly approaching that of interstellar space. As a matter of fact, one side of the earth would thus probably become too hot for habitation and the other would certainly be too cold. As far as Mercury is concerned this state of things has already been reached, and there is little doubt that this planet is entirely unfitted for the abode of any kind of life which we can mention. Mercury possesses no satellites: Its apparent movements and orbit will be described along with those of Venus.

Venus. Venus, which is the brightest and most beautiful star in the heavens, is our nearest planetary neighbour, coming at times within about 25,000,000 miles of the earth. Its distance from the sun is 67,200,000 miles, and it therefore receives just twice as much heat and light as the earth. Its orbit is almost exactly circular, and the length of its year is 225 days. Its orbit is inclined to the ecliptic at an angle of 3½°. The diameter of Venus is about 7700 miles, or very slightly less than that of the earth.

The planet rotates on its axis, but here again, as in the case of Mercury, there is great difficulty in measuring its angular velocity, owing to the apparent covering of the planet with clouds which afford no definite fixed point for our telescopes to watch. The best modern opinion is that Venus, like Mercury, has a day of the same length as its year, and continually presents the same face to the sun. If this be the case, Venus, like Mercury, must be unfitted to be the abode of life, and it is, to say the least, doubtful whether the proximity of these planets to the sun ever allowed life, which seems to us to be limited to a very moderate range of temperature, to be developed upon their surface. Venus appears to be surrounded by an atmosphere of considerable density, and possesses no known satellite.

Morning and Evening Stars. The apparent motions of Mercury and Venus present great similarity, and may conveniently be described together. They are both visible at different times of the year as morning or as evening stars. Venus is pre-eminently known as the Evening Star or Morning Star, on account of its resplendent beauty, "sweet Hesper-Phosphor, double name." Mercury, though very nearly as bright as Venus, is very much less easy to perceive, on account of its greater proximity to the sun. The great astronomer Copernicus is said to have passed his whole

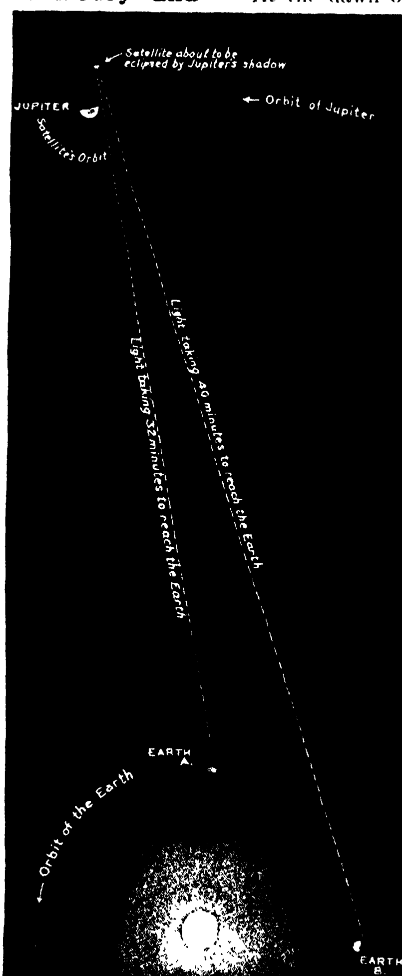
life in unavailing endeavours to perceive Mercury—though this is perhaps an exaggeration. The planet can be seen several times a year by those who know where to look, but it is generally drowned in the sun's radiance. Everyone, however, is familiar with the brilliant appearance of Venus, whether shining as the Evening Star after sunset or as the Morning Star which heralds the appearance of the sun.



THE ORBIT OF VENUS AS SEEN FROM THE EARTH, SHOWING THE APPARENT CHANGES OF THE PLANET

Apparent Motions of Mercury and Venus. The essential peculiarity of the motions of Mercury and Venus is that they are never seen very far away from the sun. Mercury never remains visible for more than an hour or so after the sun has set, and Venus is always seen as an evening star in the west or a morning star in the eastern sky. They are never visible, like others of the planets, right overhead. If we study the motions of Mercury or Venus from night to night, we very soon begin to perceive the irregular changes. Venus, being so much easier to perceive, offers a good object for the young astronomer to watch from week to week.

After a while it becomes apparent that this planet moves backward and forward on either side of the sun, within a limited range. Suppose that at the time of beginning our watch Venus is shining as the brilliant Evening Star after sunset. For a time it seems to travel farther and farther eastward, or away from the sun, and consequently to remain visible for a longer time each evening. But the time soon comes when we notice that it ceases to go farther away from the sun; it remains stationary for a night or two, and then it begins to travel back toward the sun, until it is entirely swallowed up in the solar radiance and is invisible for a time. After a short period of invisibility, Venus emerges on the other side of the sun and consequently becomes visible in the morning shortly before sunrise. As it continues to move to the west of the sun, it rises earlier and earlier, till again it reaches the limit of its western motion, remains stationary for a short time, and then again starts on its eastward journey back toward the sun, ultimately to emerge on the eastern side of the sun and again become the Evening Star.



HOW THE VELOCITY OF LIGHT WAS DISCOVERED BY ROEMER

The eclipses of Jupiter's satellites occurred later or earlier than anticipated by Roemer, that when the earth was at B in its orbit taking place eight minutes later than calculations made for the earth 100 million miles nearer at A. This enabled Roemer to arrive at the actual velocity of light.

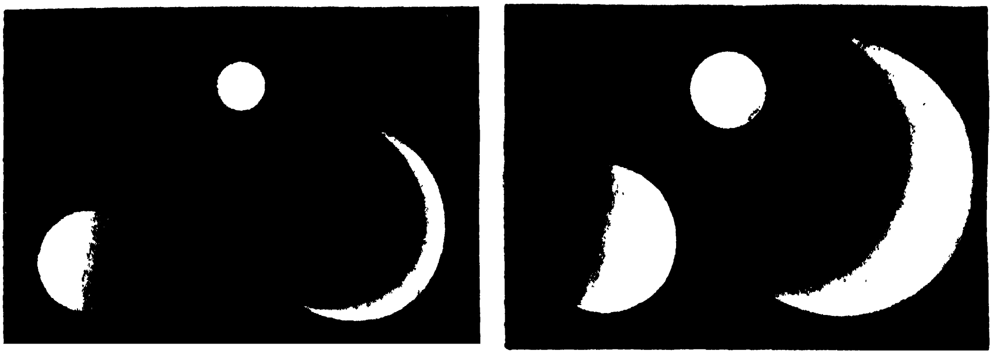
At the dawn of astronomy the Morning and Evening Star were supposed to be distinct bodies, which were named Phosphorus and Hesperus; one of the first astronomical discoveries was that they were really the same star, which journeyed backward and forward from one side of the sun to the other. The apparent motion of Mercury is precisely similar, though less easy to watch because it is confined within much narrower limits. The angular distance of these planets from the sun on either side is known as their *elongation.* When they are in a straight line with the sun and earth, the planets are said to be in *conjunction.*

The Orbits of the Evening Stars. The real explanation of these motions is not difficult to comprehend. Venus and Mercury both move round the sun in roughly circular orbits inside that of the earth. Consequently the effect of perspective shows them to us as if they moved in a straight line backward and forward from the sun. If the earth were at rest, each planet would complete its double oscillation in the period of its year. Venus, for instance, would pass from her farthest eastern to her farthest western elongation in 225 days. But as the earth is also in motion round the sun, this simple motion is complicated by our own motion. Instead of the easterly and westerly motions of

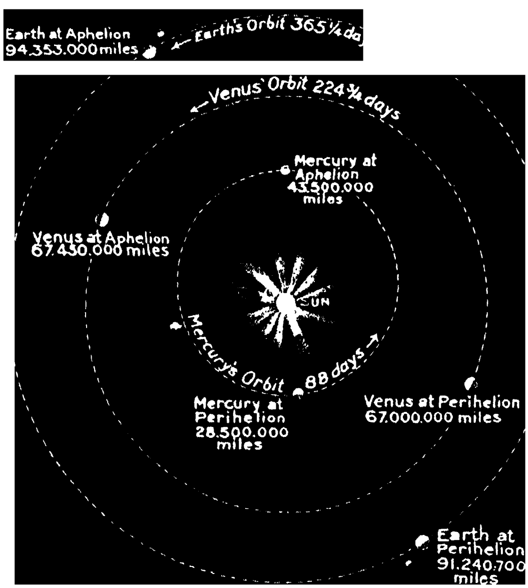
Venus or Mercury being completed in the same time, the westward swing appears to be completed much more rapidly than the eastward, because in the former case the earth's motion assists that of the planet, but in the latter it detracts from it. Thus, Venus moves rapidly from its easterly elongation as the Evening Star to its westerly elongation as the Morning Star, and travels back again much more slowly.

Its *synodic* period, or the period in which it completes this cycle with reference to the earth, is 584 days; more than three-quarters of this period is occupied in the slower half of the journey. The synodic period of Mercury is 116 days. The greatest elongation of Venus, or its apparent distance from the sun, varies from 47° to 48°, which means that when it is farthest away from the sun it may be visible for more than three hours after sunset or before sunrise. Mercury's greatest elongation varies from 18° to 28°, so that under the most favourable circumstances it is visible for less than two hours before sunrise or after sunset. One of the first discoveries made by Galileo's telescope, which, as we read on page 63, he himself invented, was that these two planets, Mercury and Venus, exhibited phases like those of the moon. The other planets always shine with a full circular disc, though it varies in apparent size with their varying distance from the earth. But Venus and Mercury, when seen through a telescope, present the phases with which we are so familiar in the moon. These phases will be readily understood by a glance at the diagram. They depend, of course, upon the fact that the planet derives its light by reflection from the central sun, and moves round the sun between it and the earth. When at *inferior* conjunction the planet is between us and the sun we see only its dark side, or, in other words, do not see it at all. As a matter of fact, it is then swallowed up in the sunbeams, and the only occasion when we have an opportunity of testing the truth of this part of the theory is when Venus or Mercury passes right between us and the sun. It then appears in *transit* as a circular black spot on the sun's disc.

At the *superior* conjunction it is beyond the sun, and nearly in a straight line with it from the earth. At these times we cannot see it at all, because of the solar brilliance; but if we could see



MERCURY AND VENUS AT THEIR GREATEST, LEAST, AND MEAN DISTANCES FROM THE EARTH

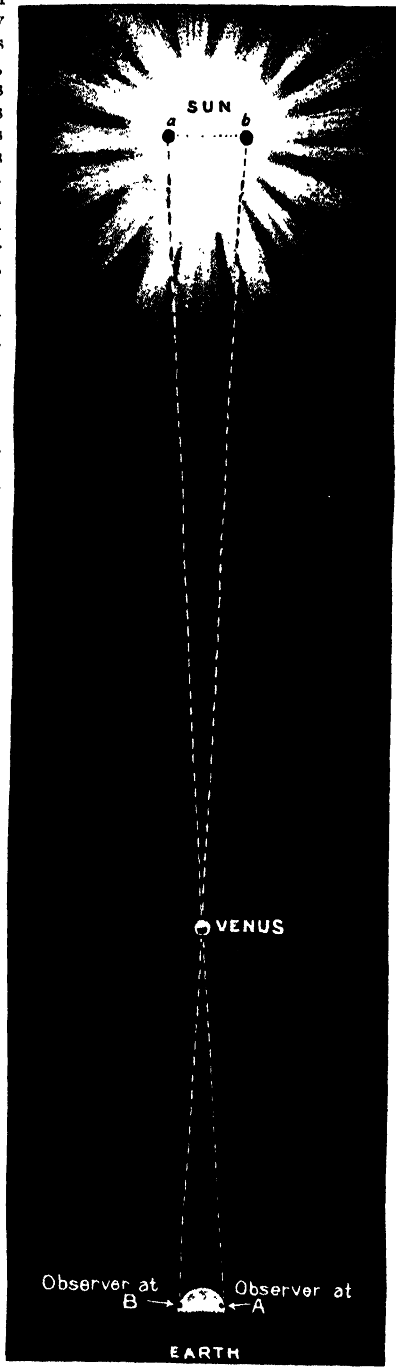


THE ORBITS OF THE EARTH, VENUS, AND MERCURY

THE ELLIPSES OF THE PLANETS SEEN EDGEWISE—WITHOUT REGARD TO THEIR RELATIVE PROPORTIONS

it we should see its disc fully illuminated like that of the moon. At the times of greatest elongation the planet appears like a half-moon; a good field-glass or small telescope will clearly show these phases when Venus is shining as the Evening Star, from two to three hours after sunset. At other times the planet exhibits various lunar phases, being gibbous as it passes from one elongation to the other beyond the sun, and waning to a crescent as it completes the other half of its orbit. The same explanation applies to Mercury, though its proximity to the sun makes its phases less easy to follow.

The Earth as a Planet. The third planet in order of distance from the sun is by far the most interesting of all, because it is the earth on which we live. Some explanation must here be given of the way in which astronomers have measured the size of the earth's *orbit*, or annual path round the sun, which affords a basis for all our measures of celestial distances. In the first place it must be said, though the explanation of the fact must be looked for in more advanced treatises, that the mathematical theory of astronomy, based on Newton's law of gravitation, gives us all the *relative* measurements of the solar system with great accuracy, but does not determine any one of them *absolutely*. That is to say, if we know any one of these measurements, we can easily calculate all the others in terms of it. The most obvious measurement to use as a basis or unit is the distance of the earth from the sun. The early Greek astronomers made ingenious but futile attempts to calculate this by geometrical constructions, but the problem was too complicated for them. Modern researches have been carried on by means of two distinct methods, which have yielded results practically similar, and have enabled us to measure the earth's mean distance from the sun within a scarcely appreciable margin of error.



FINDING THE DISTANCE OF THE SUN

This method, propounded by Edmund Halley in the eighteenth century, depends on observations of the Transit of Venus across the sun taken from different points on the earth. The method is described in the text in this page.

The Sun's Parallax. The first and older of these methods depends on what is called *parallax*. Parallax is a name given to the difference between the directions of a celestial body as seen from two different points. It is the same principle which is utilised in the trigonometrical operations of ordinary surveying. The surveyor measures the base line AB of a triangle in order to determine the position of a third point C. He then sets up his theodolite, first at A, and then at B, and measures the angles CAB and CBA—or, in popular language, the difference of direction of C, as seen from A and B. When the length AB and any two of the angles of the triangle ABC are known, it is a simple trigonometrical calculation to find the length of the other sides CA and CB. In celestial surveying, or astronomy, we begin by measuring a base line on the earth.

In Halley's method observers at two points, A and B, which constitute the ends of a base line on the earth, see the disc of Venus, when in transit, projected on the sun at *a* and *b*. The length of a line connecting *a* and *b* on the sun represents the parallax, which in this case is exceedingly small. As the exact measurement of the base line AB on the earth is known, this, together with mathematical calculations enables astronomers to know how long the base line AB on the earth would appear as seen from the sun. The apparent sizes of objects are known always to diminish in a certain ratio in proportion to their distance, therefore it becomes a simple matter to calculate how far their distance is.

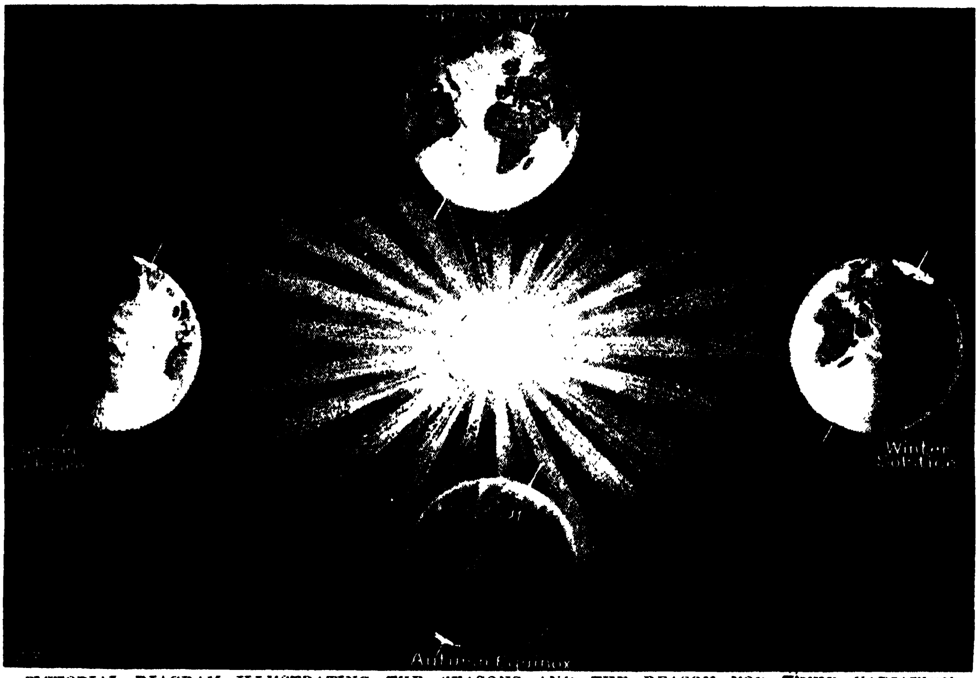
This is merely a rough illustration of the method used, which is really much more elaborate and involves a great many minute corrections which we have no space to explain. But the principle of it will now be clear. Such measurements require to be made with the greatest accuracy, because the distance of the sun from the earth is so great in comparison with

the longest base that can be drawn on the earth that the difference between the directions from which it is seen from any two points at the same time is exceedingly small.

There is, however, another quite independent method of estimating the distance of the sun. It will be clear that we could measure the distance from London to Edinburgh with considerable accuracy if we knew that a motor-car, built so as to run uniformly at twenty miles an hour, had taken a specified time over the journey. We have a messenger of this kind, warranted to move with a perfectly uniform speed, in the ethereal vibrations which constitute light. It was discovered over 200 years ago that light did not traverse space instantaneously, but took a definite time in completing a journey of a given length. In the course of its yearly journey the earth moves from end to end of the diameter of its orbit—a gigantic base line of more than 180,000,000 miles.

The Sun's Distance Measured by the Speed of Light. The Danish astronomer Roemer found that his observations of the eclipses of Jupiter's satellites, whose motions are so well known that the times of these eclipses can be calculated in advance, varied as much as sixteen minutes from one another at different times of the year. Some of his observations showed that these eclipses happened about eight minutes sooner than the predicted time. Six months later the observation was eight minutes behind the time given in the tables. It is from such discrepancies between calculated events and observations made as accurately as possible that a great many of the most valuable scientific discoveries have arisen, because they always point to the existence of some previously unsuspected cause which modifies the phenomena under study.

Roemer, on thinking it out carefully, saw that the only difference in the conditions between the two sets of observations was that the earth was at opposite ends of its annual journey; in other words, its distance from Jupiter, which does not move far in six months, varied in that time by about the diameter of the earth's orbit, or twice the distance from the sun to the earth. He then saw that if he assumed that light took about eight minutes to travel from the earth to the sun, the discrepancies between his observations and the predicted times of eclipses might be satisfactorily explained. These eclipses having been calculated with the sun as starting point, when the earth was at its nearest approach to Jupiter, light from that planet, bearing the message of the eclipse, would reach it eight minutes sooner than the sun, and, consequently, the eclipse would seem to happen eight minutes too soon. Similarly, six months afterwards, when the earth had rushed to the other end of its orbit, the light would have to pass the sun and travel on as far again, and the eclipse would appear to happen eight minutes later.



PICTORIAL DIAGRAM ILLUSTRATING THE SEASONS AND THE REASON FOR THEIR VARIATION
This diagram shows the position of the British Isles in relation to the sun in the middle periods of the four seasons, and explains why the sun's rays fall more directly on them in summer than in winter owing to the unvarying tilt of the spinning earth

The Fundamental Astronomical Unit. It is possible with the exact instruments of modern science to measure the velocity of light in our laboratories, and from such observations as those of Roemer can be measured, with equal accuracy, the time which light takes to travel from the earth to the sun. This physical method of measuring the sun's distance is quite

independent of the parallactic or astronomical one, and the two give results closely in accordance with one another. From these various methods the earth's distance from the sun is known to be about 92,900,000 miles, the probable error not being greater than 100,000 miles either way. This distance of the sun is the fundamental unit of astronomical measurements, in terms of which all others are calculated, though we shall see when we come to the fixed stars that a larger unit has there to be adopted.

When the actual distance of the earth from the sun has been found by either of these methods, all the other dimensions of the earth's orbit and the rest of the solar system can be calculated from it. Another very important unit is the earth's *mass*, which is found by experiment, and from which the laws of dynamics enable us to calculate the mass of all other bodies which compose our system. There are various methods of weighing the earth, which all depend on the principle by which the mass of any comparatively small quantity of matter is determined.

How the Earth is Weighed. The most trustworthy of these is that used by Cavendish, the famous chemist of the eighteenth century, and generally associated with his name, though later workers have obtained still more accurate results from its use. The law of gravitation tells us that two masses attract one another with a force which is always proportional to the product of their masses. The *Cavendish experiment* consists in measuring the attraction which a massive globe of lead has for a small pith ball, and comparing this attraction with the weight of the pith ball. The weight of a body is simply a convenient way of measuring the attraction which the earth has for it; we are, therefore, able to say that the mass of the earth is to the mass of the leaden globe as the weight of the pith ball is to the force with which the leaden globe would attract it if placed at the same distance away from it as the centre of the earth, from which terrestrial gravitation is measured. The observation is a very delicate one, as it involves measuring forces not greater than the weight of the millionth part of a grain; but considerable reliance is placed on its results, and the density of the earth is known with fair accuracy to be about $5\frac{1}{2}$ times that of water.

The Actual Weight of the Earth. Other methods used for determining the mass of the earth, such as the Schehallien and the Harton experiments, are much less trustworthy, but on the whole lead to the same result. From the known size of the earth we can calculate its volume, and its mass being determined by the Cavendish experiment gives us its mean density. The actual mass of the earth is 6×10^{21} tons—or 6 with 21 noughts after it. This gigantic mass cannot be realised by any mental process of which we are capable. In astronomical work the mass of the earth is taken as the unit to which the mass of other celestial bodies is referred. Thus, the mass of the sun is given as 332,000 times that of the earth; and Jupiter, the largest of the planets, is 317·7 times as massive as the earth.

The Orbit of the Earth. The earth's orbit, as we have already seen, is an ellipse of which the sun occupies one focus. This orbit is very nearly circular, the eccentricity of the ellipse being only about $\frac{1}{60}$th. The points in the orbit at which the earth is nearest to and farthest from the sun are respectively known as the *perihelion* and the *aphelion*. The earth reaches its perihelion about December 31st, and its aphelion early in July. It would seem at first that the earth should be nearest to the sun in summer and farthest from it in winter. But our seasons depend upon the fact that the earth rotates about an axis which is inclined to the plane of its orbit at an angle of rather more than 23°. This axis always remains pointing to the same points in the sky, which are known as the celestial poles.

When the earth is in perihelion its north pole is inclined away from the sun, whence it follows that in the northern hemisphere the nights are then longer than the days, and the total quantity of light and heat which that hemisphere receives from the sun is a minimum, while in the southern hemisphere these conditions are exactly reversed. Consequently when the earth is in perihelion it is mid-winter in the northern and mid-summer in the southern hemisphere; when it is in aphelion it is mid-summer in the northern and mid-winter in the southern.

A Model of the Season Changes. The student will find it quite easy to understand why this is the case if he will make a rough model of the earth by running a knitting-needle through the core of an apple, and trace the equator round the middle of the apple at right angles to this axis. If he then takes a lighted candle to represent the sun and moves this model earth round it, taking care to keep the axis inclined at an angle of about 23° to the plane of the table on which the lighted candle stands, he will get a very good idea of the seasonal changes.

He will also see that there are two, and only two, points in the earth's orbit at which the plane of its equator passes through the sun. When the earth is at these points both hemispheres are equally illuminated, and day and night are of equal length, whence these points in the orbit are known as the vernal (or spring) and autumnal *equinoxes*. The points in the orbit at which the northern hemisphere has respectively its maximum and minimum illumination are the summer and winter *solstices*, because at these points in the orbit the sun has reached its highest place in the sky, and appears to stand still for a day or two before beginning its reverse journey. The sun's apparent motion in the sky is compounded of the earth's rotation and its revolution in the annual orbit. Every day it travels across the heavens from east to west, because the earth is rotating from west to east and carrying the observer with it. Every year the point where the sun *culminates*, or reaches its highest place at noon, travels steadily upwards in the sky from mid-winter to mid-summer, and then sinks down at the same rate.

W. E. GARRETT FISHER

Timber Trusses. Iron and Steel Trusses for Various Spans. Curved Trusses. The Effect of the Wind.

STRESSES IN ROOF TRUSSES

Collar Beam Truss. This truss [110], although the simplest from a constructive point of view, is by no means simple when the stresses are considered. The legs of the truss tend to spread with the weight of the covering, and the part of the principal rafters below the collar is in the condition of a lever, so that if the walls are not rigid, a bending moment is produced at the junction with the collar.

Modifications of this form are frequently used for the open roofs of churches, and the walls are only prevented from being thrust outward by their dwarf height and the buttresses placed against them opposite to each truss. When the walls are higher, the overturning effort is greater, and many cases have occurred of the walls being actually thrust out. Under such conditions the collar beam is in full tension, but any intermediate condition may occur between this and full compression owing to rigid walls.

It is this uncertainty of condition that creates the chief difficulty of estimating the stresses, but when allowance has to be made for the wind blowing on one side the difficulty is further increased. The frame and stress diagrams for vertical loading and rigid walls are shown in **111** and **112**, and for vertical loading and yielding walls in **113** and **114**. In **113** the bending moment diagram due to the leverage of the ends will be observed on the upper sides of the principal rafters. The dotted lines are virtual force lines to replace the bending moment diagram, and allow the complete stress diagram to be drawn.

King Post Truss. The king post truss [115] is the most common form for wooden roofs from 28 to 30 ft. span. The frame and stress diagrams with the wind on one side are shown in **116** and **117**. Upon a superficial view of **115** it appears as if the roof were supported by the king post standing on the tie beam, but the reverse is the case, as the tie beam is held up to the foot of the king post by an iron stirrup, as will be noticed in the diagram.

Composite Roofs. Composite roofs are formed of a combination of wood and iron, the compression members being of wood and the tension members of iron, which from its great tensile strength is more suitable, but these roofs are not very frequently adopted.

Queen Post Truss. The queen post truss [118] is a convenient form for wooden roofs of 30 to 45 ft. span. Under irregular loading, such as is produced by the wind acting upon one side, it is a deformable structure, owing to the want of cross bracing in the central space. Bending moments are caused in the tie beam, but its stiffness prevents the roof from suffering much actual change of shape. The frame diagram is shown in **119** and the stress diagram in **120**. As the latter involves some difficulty of construction, a full description will be given. First set down the load line 1 to 8 of stress diagram, join the extremities, which will give the direction of the reactions and substituted forces 1–11–10–9–8 on frame diagram without fixing the amounts. From point 2 draw an indefinite line parallel with 2–12 on frame diagram, and fix the position of point 27 upon it by a line from point 7 parallel to 7–17, then 17–9, being horizontal, will fix the position of point 9, thus obtaining the right-hand reaction. Next draw 4–15 and 5–15, giving point 15, and as points 15, 14, and 10 are all separated by parallel lines, the points will be on a straight line passing through point 15. This fixes the position of point 10, and at the same time the amount of substituted force 10 9, and as the substituted force farthest from the wind is equal to half the amount of the substituted force nearest to windward side, point 11 will be central between points 9 and 10.

SCANTLING FOR KING POST TRUSSES

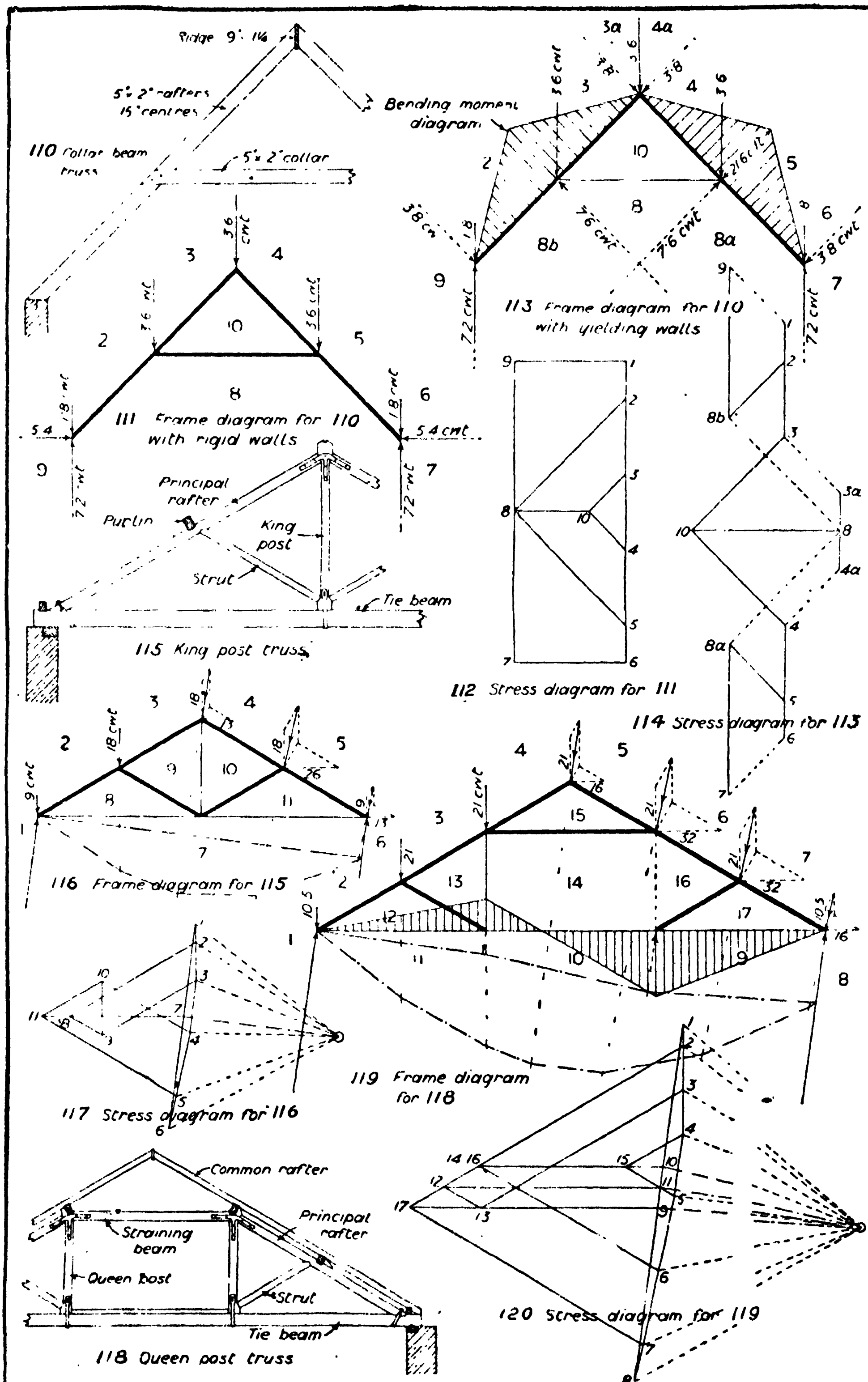
Baltic fir. 10 ft. apart. Pitch, 25° to 30°. Slated

Span Feet.	Thickness of Truss and all Members.	Breadth on Elevation.				Purlins.	Common Rafters.
		Tie Beam.	King Post	Struts	Principal Rafters		
20	4	8	3	2	4	8 × 4	3½ × 2
22	4½	9	3¼	2¼	4	8 × 4	4 × 2
24	5	10	3½	2½	4	8 × 4½	4 × 2
26	5½	11	4	2¾	4	9 × 4½	4½ × 2
28	6	12	4	3	4	9 × 5	4½ × 2
30	6½	13	4½	3¼	4½	9 × 6	5 × 2

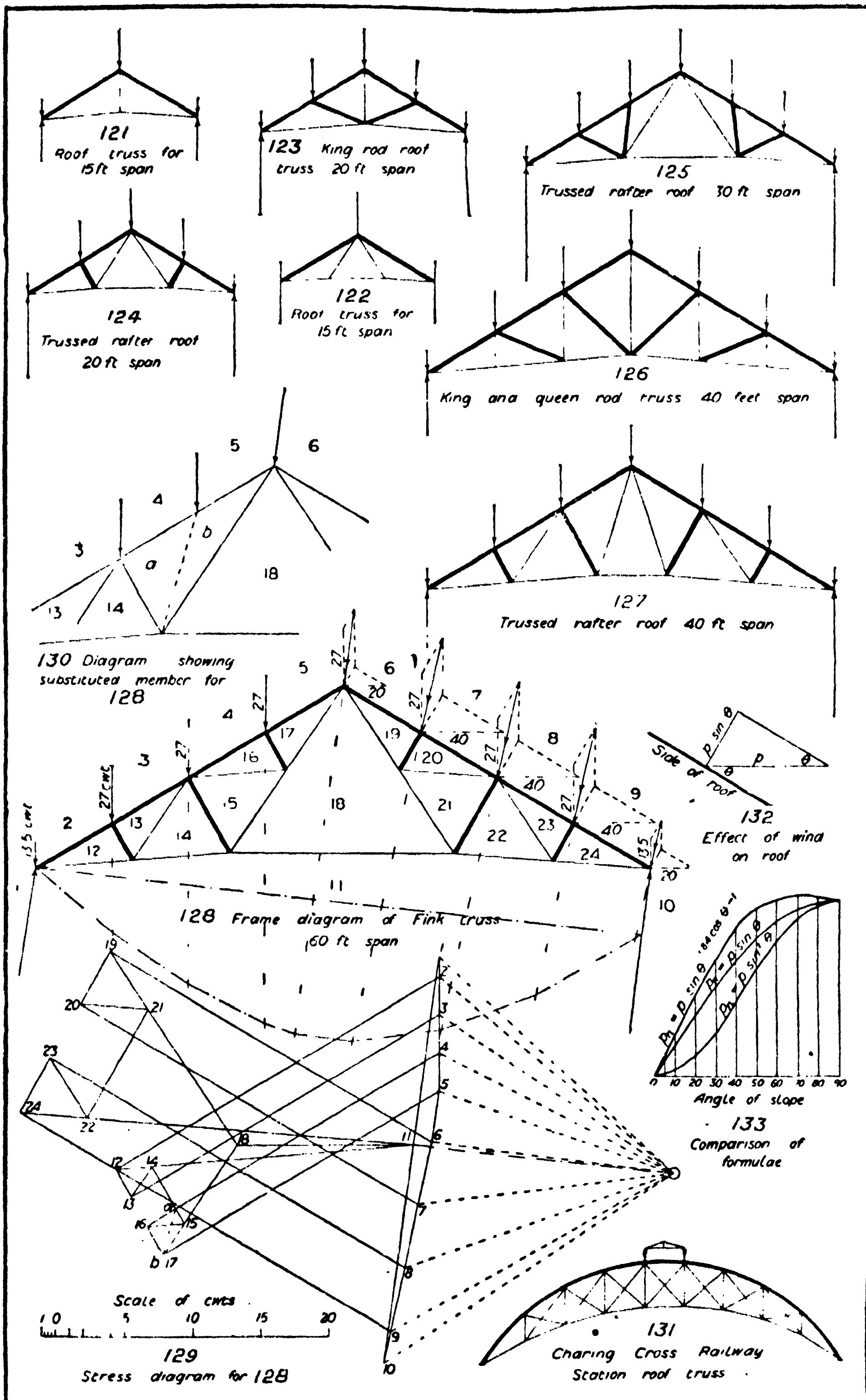
The remainder of the stress diagram presents no further difficulties, and after completion may be tested for accuracy by drawing a funicular polygon on the frame diagram as shown by stroke and dot lines, which will be found to close. The table of scantlings on this page will be found suitable for ordinary cases, and will obviate the necessity for making calculations.

The head and foot of the king post are twice the width of the middle. Reduce the thickness of truss by ½ in. and the depth of tie beam by 1 in. if there is no ceiling.

Wrought-Iron and Steel Roofs. Omitting a few cast-iron ribbed roofs, it may be said that all metal roofs were formerly of wrought iron, but the greater tenacity of mild steel and its extensive manufacture render it *the* material of the present day. The same types of construction are used, the difference being only in the lighter sections employed. The arrangement of the trussing of all roofs varies primarily with the span ; the roof covering is supported usually by "common rafters," and, in order that these may



TIMBER ROOF TRUSSES



121 Roof truss for 15 ft span

123 King rod roof truss 20 ft span

125 Trussed rafter roof 30 ft span

124 Trussed rafter roof 20 ft span

122 Roof truss for 15 ft span

126 King and queen rod truss 40 feet span

130 Diagram showing substituted member for 128

127 Trussed rafter roof 40 ft span

128 Frame diagram of Fink truss 60 ft span

132 Effect of wind on roof

133 Comparison of formulae

129 Stress diagram for 128

131 Charing Cross Railway Station roof truss

IRON ROOF TRUSSES

SCANTLING FOR QUEEN POST TRUSSES

Baltic fir. 10 ft. apart. Pitch, 25° to 30°. Slated

Span Feet.	Thickness of Truss and all Members.	Breadth on Elevation. Tie Beam.	Queen Post.	Struts	Principal Rafters.	Straining Beam.	Purlins.	Common Rafters.
32	4	9	4	2	4½	6	8 × 4	3½ × 2
34	4½	10	4	2	5	6½	8 × 4	4 × 2
36	5	10½	4½	2	5½	7	8 × 4½	4 × 2
38	5½	11	4½	2	5½	7½	8 × 4½	4 × 2
40	5½	11½	5	2½	6	8	9 × 4½	4½ × 2
42	6	12	5	2½	6	8	9 × 4½	4½ × 2
44	6	12½	5½	2½	6½	8½	9 × 5	4½ × 2
46	6	13	6	2½	7	9	9 × 6	5 × 2

have economical dimensions, the purlins that carry them require to be within certain limits of spacing, say 5 to 10 ft. apart. This spacing fixes the position of the supports to the principal rafters, and therefore the number of bays into which they are divided. The distance apart of the trusses is partly determined by the strength of suitable purlins and partly by the desirability of securing a sufficient load upon each truss to obtain convenient and economical sections of the various members. Owing to the necessity of providing against the effects of corrosion, no bar or plate may be less than ¼ in. thick or ½ in. diameter, and where the load is very light, some material may be practically wasted from this cause. The external pitch of a roof is fixed by the nature of the covering and climatic or æsthetic conditions; the under side may be varied by giving more or less camber to the tie rods at pleasure, and this affords another means of adjusting the stresses in the members to an economical value, the stresses being increased as the camber is greater owing to the reduction of the central depth.

Number of Bays for Given Spans. The following table gives the average practice for iron and steel roofs, but so many points have to be considered in designing roofs that no precise rule can be laid down.

1 bay in rafter is suitable for roofs up to 15 ft. span.

2 bays in rafter are suitable for roofs 15 to 30 ft. span.

3 bays in rafter are suitable for roofs 25 to 50 ft. span.

4 bays in rafter are suitable for roofs 40 to 75 ft. span.

5 bays in rafter are suitable for roofs 60 to 100 ft. span.

Iron roofs to cover a large area are generally cheaper when the number of separate roofs is reduced and the trusses increased in span up to a maximum of 60 ft., owing to the more accurate proportioning of the material to the stress and the saving of supports.

Types of Construction for Various Spans. Typical arrangements of trusses with the principal rafters divided into one to four bays are shown in outline in **121** to **128**. With the exception of **128**, these involve no difficulty in determining the stress diagram and resultant stresses so that they need not be dealt with further; but the one referred to, known as a Fink, French, or Belgian truss or compound trussed rafter roof will well repay a more detailed investigation.

Fink Truss. Having drawn the frame diagram and marked on the external loads, set down the load line of stress diagram [**129**], join the extremities, and proceed with the diagram in the usual manner until point 14 is reached, when it will be found that point 15 cannot be obtained as only one of the surrounding spaces is known—*viz.*, 14, and it is at this point that the method of *substituted members* will have to be resorted to, in order to find point 18. For the members 15, 16, 17 on frame diagram substitute the member *a-b*, as shown for clearness on separate sketch [**130**], then, turning again to the stress diagram, draw 14-*a*, 4-*a*, giving point *a*; *a-b*, 5-*b*, giving point *b*; and *b*-18, 11-18, obtaining point 18. The remainder of the diagram may now be added without further difficulty.

Curved Trusses. A crescent or sickle-shaped truss is sometimes used for large roofs, as in the case of the Charing Cross, Cannon Street, and Fenchurch Street railway-stations in London. In such cases it is necessary to provide cross bracing to allow for the effect of the wind on one side or the other, so that whichever side it blows from one member of the cross bracing in each bay will take the whole of the load as a tensile stress. The Charing Cross truss is shown in **131**.

Effect of Wind. It is not an easy matter to measure the velocity of the wind, and it is still more difficult to estimate its force against a plane surface in any position. Although consideration has been given to the subject for more than a hundred years there is still a need for practical investigation upon a large scale. It may, however, be assumed that in ordinary positions a pressure of 28 lb. (¼ cwt.) per square foot is very rarely exceeded, and that in the most exposed positions an allowance of 56 lb. (½ cwt.) per square foot will cover all contingencies. The larger the area taken into account at one time the lower the pressure is likely to be. It does not always blow horizontally, and when there are many buildings in the neighbourhood it may be deflected downwards upon any given roof. Assuming the wind to blow horizontally with a force of 42 lb. per square foot against a roof of 30 degrees pitch the effect normal to the roof plane [**132**] will be reduced to $p \sin \theta = 42 \times \sin 30° = 21$ lb. In the same way, if the wind be assumed to blow horizontally with a force of 56 lb. per square foot the normal pressure will be reduced to 28 lb. Authorities are, however, not agreed as to the true normal pressure, some take it as the $p \sin \theta$, others $p \sin^2\theta$, and still others as $p \sin \theta^{1 \cdot 84 \cos \theta - 1}$. These values are contrasted in the curves shown in **133**.

HENRY ADAMS

A Third Lesson in German, and further chapters in English and French

GERMAN

Continued from page 652

By P. G. Konody and Dr. Osten

Gender of Nouns

VII. In German the following are of MASCULINE GENDER:

- (*a*) the substantives, denoting male persons and animals, and many inanimate objects;
- (*b*) the names of the seasons, months, days, stones, and points of the compass.
- (*c*) all nouns ending in m, except those of Latin origin.

EXAMPLES. (*a*) der Sohn, son: der Bruder, brother; der Onkel, uncle; der Knabe, boy; der Greis, old man (greybeard); der Löwe, lion; der Tiger, tiger; der Bär, bear; der Wolf, wolf; der Adler, eagle; der Falke, falcon; der Sperling, sparrow; der Berg, mountain; der Fluß, river; der Baum, tree; der Wind, wind.

(*b*) der Frühling, Spring; der Sommer, Summer; der Herbst, Autumn; der Winter, Winter; der Monat, month; Jänner (also Januar), January; der Februar, February; der März, March; der April, April; der Mai, May; der Juni, June; der Juli, July; der August, August; der September, September; der Oktober, October; der November, November; der Dezember, December; but das Jahr (*n.*), the year; die Woche (*f.*), the week; der Tag, the day; and die Nacht, the night; der Montag, Monday; der Dienstag, Tuesday; der Mittwoch, Donnerstag, Freitag, Samstag (or Sonnabend), Sonntag, (Wednesday, Thursday, Friday, Saturday, Sunday); — der Stein, stone; der Diamant, diamond; der Rubin, ruby; der Smaragd, emerald; der Kiesel, pebble; der Marmor, marble; der Granit, granite; der Norden, the north

(*c*) der Sturm, storm; der Schwarm, swarm; der Arm, arm; der Wurm, worm; der Lärm, noise; der Atem (or Odem), breath.

EXCEPTIONS: die Form, form; die Farm, farm; das Publikum, the public; and other derivations from the Latin.

There are of course many other nouns of masculine gender, but there are so many exceptions to the rules which could be formed that it is simpler to follow the practice of learning each noun with its definite article.

Thus, *e.g.*, der Schall, sound; but das Metall, metal; and die Nachtigall, nightingale; der Nebel, fog; but die Nadel, needle; and die Fabel, fable; der Ring, ring; but das Ding, thing; der Magen, stomach; but das Eisen, iron; der Hafer, oats; but die Mauer, wall; and das Fenster, window.

1. The grammatical and natural gender do not always coincide in German. Thus the diminutives of masculine and feminine nouns are neuter, and are formed by the suffixes -chen or lein: der Vater — das Väterchen (or Väterlein), little father; der Mann — das Männchen (or Männlein), little man; die Mutter — das Mütterchen (or Mütterlein), little mother; die Tochter — das Töchterchen (or Töchterlein), little daughter.

NOTE. das Weib, woman; das Fräulein, young lady; das Mädchen, girl. Die Waise, orphan; der Säugling, baby or infant; and das Kind, child; are used for both sexes.

Gender of Adjectives

VIII. The ADJECTIVE agrees (*a*) in gender, number and case with the substantive which it precedes (*Attributive Adjective*). When used as *Predicate* (*b*), that is to say, after the auxiliary verbs sein and werden, it remains unaltered.

EXAMPLES: fleißig, diligent; gut, good; schlecht, bad; schön, beautiful; häßlich, ugly; reich, rich; arm, poor; hoch, high; stark, strong; schwach, weak; kurz, short; lang, long; rot, red; grün, green; weiß, white; blau, blue; gelb, yellow; schwarz, black; grau, grey; braun, brown; kalt, cold; warm, warm; lau, tepid, heiß, hot; naß, wet trocken, dry.

(*b*) Der Knabe ist fleißig, the boy is diligent; die Frau ist fleißig, the woman is diligent; das Kind ist fleißig, the child is diligent.

(Examples for (*a*) will follow in the chapter dealing with the declension of the adjective.)

The Interrogative

IX. The DIRECT QUESTION is formed by placing the verb with the personal termination at the beginning of the sentence. Thus in the sentence: ich habe geschlafen (I have slept); habe is the verb with the personal termination, and the form of question would be: Habe ich geschlafen?

Examples.

Ich bin arm,	Sind wir reich?
I am poor,	Are we rich?
Bin ich arm?	Die Frau hat ein Kind.
Am I poor?	The woman has a child.
Wir sind reich,	Hat die Frau ein Kind?
We are rich,	Has the woman a child;

1. Under no circumstances is the verb thun (to do) to be used in questions, as in English. Thus, Do you speak German? is *never* translated: Thun Sie deutsch sprechen? but always: Sprechen Sie deutsch? (Speak you German?)

Did you speak German? is always rendered as: Spoke you German? (Sprachen Sie deutsch?)

Conjugations of Verbs

X. The CONJUGATION OF THE VERB is either weak, strong, or mixed. The majority of German verbs take the weak conjugation.

1. The distinguishing feature of the weak and strong conjugations is the formation of the *Imperfect*, the former by suffixes alone, and the latter by change of the stem vowel. The weak verbs *never* modify the stem vowel.
2. Inflections of weak or regular verbs in the Present Tense:

Indicative.

-e	ich lob-e	I praise.	
-est or -st	du lob(e)-st	thou praisest.	
-et or -t	er lob(e)-t	he praises.	
-en	wir lob-en	we	praise.
-et or -t	ihr lob(e)-t	you	
-en	sie lob-en	they	

Subjunctive

-e	ich lob-e	I may praise.	
-est	du lob-est	thou mayest praise.	
-e	er lob-e	he may praise.	
-en	wir lob-en	we	may praise.
-et	ihr lob-et	you	
-en	sie lob-en	they	

3. The -e of the inflections in the *2nd* and *3rd pers. sing.* and *2nd pers. plur.* is generally dropped in the *Indicative*, but retained in the *Subjunctive* of verbs with stems ending in -d, -st, -t, -th; (red-en, to speak; röst-en, to roast; läut-en, to ring; erröth-en, to blush; etc.), and wherever its omission would result in harsh or difficult pronounciation, for instance, in the *2nd pers. sing. indic.* of verbs with stems ending in hissing sounds: -s, -ss, sch, z; like: speis-en, to dine or eat; hass-en, to hate; lausch-en, to listen; schmatz-en, to smack one's tongue; etc. — speisest, hassest, etc.
4. Verbs ending in -eln cast off the e of this suffix in the *1st pers. sing. indic.*, for similar reasons of euphony: handeln, to act, to bargain, ich hand(e)l-e; lächeln, to smile, ich läch(e)l-e. The e is, however, retained in the *2nd* and *3rd pers. sing.*: du handel-st, er lächel-t, and so on.

EXAMINATION PAPER III

EXERCISE 1. Insert in the dotted places the auxiliary verbs haben (to have) and werden (to become, to get), and the articles.

Ich .... Vater und .... Mutter. Du .....
I have a father and a mother. Thou growest
stark. Er .... Lehrer. ... Frau ... ...
strong. He has a teacher. The woman has a
Mann. .... Kind .... fleißig. ....
husband. The child becomes diligent. The
Mütter .... Kinder. ... Männer .... Fisch.
mothers have children. The men have a fish.
Ihr .... Onkel; sie .... Sohn.
You have a uncle; they have a son.
.... Mädchen ..... schön.
The girl becomes (is getting) beautiful.
.... Kinder .... fleißig.
The children become diligent.

EXERCISE 2. Insert the definite article.

.... Bruder .... Mutter ist ... Onkel ... Sohnes.
The brother of the mother is the uncle of the son.
.... Löwe ist stark. .... Berg ist hoch.
The lion is strong. The mountain is high.
.... August ist warm. .... Frühling ist schön.
[The] August is warm. Spring is beautiful.
.... Tage werden kurz. .... Südwind ist warm.
The days become short. The south wind is warm.
.... Rubin ist rot, ... Smaragd grün und
The ruby is red, the emerald green, and
... Diamant weiß. .... Stall ist trocken.
the diamond white. The stable is dry.
... Hafer ist nass. .... Metall ist weiß.
The oats are [is] wet. The metal is white.
.... Säbel ist scharf. ..... Nadel ist gut.
The sword is sharp. The needle is good.
.... Wurm ist schwach. .... Arm ist stark.
The worm is weak. The arm is strong.
.... Weib ist .... Mütterchen .... Mädchens.
The woman is the [*dimin.*] mother of the girl.
.... Männlein is .... Vater .... Fräuleins.
The [*dimin.*] man is the father of the young lady.
.... Knabe ist .... Waise.
The boy is an orphan.
.... Säugling ist .... Mädchen.
The baby is a girl.

EXERCISE 3. Insert the conjugational terminations to the stems of the verbs.

Ich arbeit... fleißig. Der Schüler lern...
I work diligently. The scholar (pupil) learns.
Wir schreib... Briefe. Du arbeit... Ihr lob...
We write letters. Thou workest. You praise
die Kinder. Der Lehrer lob... den Schüler.
the children. The teacher praises the pupil.
Sie lieb.... die Kinder. Sie lieb.... die Kinder;
They love the children. You love the children.
sie lieb... die Kinder.
she loves the children.

Declension of Pronouns

XI. THE DECLENSION OF THE PERSONAL PRONOUNS. (The numbers 1—4 indicate the four cas

	Singular 1st Person		*2nd Person*		*3rd Person*					
1.	ich	I	du	thou	er	he	sie	she	es	it
2.	meiner (mein)	of me	deiner (dein)	of thee	seiner (sein)	of him	ihrer	of her	seiner (sein)	of it
3.	mir	to me	dir	to thee	ihm	to him	ihr	to her	ihm	to it
4.	mich	me	dich	thee	ihn	him	sie	her	es	it
	Plural		*Plural*		*Plural (for all 3 genders)*					
1.	wir	we	ihr	you	sie	they				
2.	unser	of us	euer	of you	ihrer	of them				
3.	uns	to us	euch	to you	ihnen	to them				
4.	uns	us	euch	you	sie	them				

The bracketed form oi the *2nd. pers. sing.* mein, dein sein, is sometimes used in poetry, proverbs, and exalted speech.

ENGLISH

Continued from page 788

By Gerald K. Hibbert, M.A.

VERBS—continued.

COMPLETE CONJUGATION OF THE VERB "TO SEE."

Active Voice.—Infinitive Mood.

Present Indefinite : (To) see
Present Incomplete : (To) be seeing
Perfect : (To) have seen
Continuous Perfect : (To) have been seeing

Participles.

Incomplete : Seeing. *Perfect :* Having seen
Continuous Perfect : Having been seeing

Indicative Mood.

PAST.	PRESENT.	FUTURE.
	Indefinite.	
I saw (*or*, did see)	I see (*or*, do see)	I shall see
	Incomplete.	
I was seeing	I am seeing	I shall be seeing
	Perfect.	
I had seen	I have seen	I shall have seen
	Continuous Perfect.	
I had been seeing	I have been seeing	I shall have been seeing

Imperative Mood.

Singular : See (thou). *Plural :* See (ye)

Subjunctive Mood.

PAST.	PRESENT.
Indefinite.	
I saw	I see
I should see	I may see
I might see	
Incomplete.	
I were seeing	I be seeing
I should be seeing	I may be seeing
I might be seeing	
Perfect.	
I had seen	I have seen
I should have seen	I may have seen
I might have seen	
Continuous Perfect.	
I had been seeing	I have been seeing
I should have been seeing	I may have been seeing
I might have been seeing	

Passive Voice.—Infinitive Mood.

Indefinite.	*Perfect.*
To be seen	To have been seen

Participles.

Indefinite : Being seen.
Perfect : Seen, *or* having been seen.

Indicative Mood.

PAST.	PRESENT.	FUTURE.
	Indefinite.	
I was seen	I am seen	I shall be seen
	Incomplete.	
I was being seen	I am being seen	I shall be being seen
	Perfect.	
I had been seen	I have been seen	I shall have been seen

(No Continuous Perfect in the Passive.)

Imperative Mood.

Singular : Be (thou) seen
Plural : Be (ye) seen

Subjunctive Mood.

PAST.	PRESENT.
Indefinite.	
I were seen	I be seen
I should be seen	I may be seen
I might be seen	
Incomplete.	
I were being seen	I be being seen
I should be being seen	I may be being seen
I might be being seen	
Perfect.	
I had been seen	I have been seen
I should have been seen	I may have been seen
I might have been seen	

The four simple tenses of the Active Voice are now given in full :

Indicative Mood.

PAST INDEFINITE.		PRESENT INDEFINITE.	
I saw	We saw	I see	We see
Thou sawest	You saw	Thou seest	You see
He saw	They saw	He sees	They see

Subjunctive Mood.

PAST INDEFINITE.	PRESENT INDEFINITE.	
(Same as Indicative.)	I see	We see
	Thou see	You see
	He see	They see

The Compound Tenses are conjugated exactly like the corresponding tenses of "be" and "have," except those tenses of the subjunctive containing *may*, *might*, and *should*. These will be dealt with below.

Impersonal Verbs. In such expressions as "it thunders," "it hails," "it behoves," "it seems," the subject is general and undefined. The *it* does not represent any definite noun as the subject. In "it thunders," for example, there is no particular *it* that is thundering : we simply mean "there is thunder somewhere." These verbs are therefore called *Impersonal*, there being no person expressed or understood as subject. They are always in the third person singular, though, of course, they can be of different tenses—*e.g.*, *it thundered*, *it will hail*. While *it* is usually employed as the grammatical subject of such verbs, occasionally there is no subject expressed at all : as, *methinks* (= it seems to me), *meseems*, *maybe* ; also, *if you please*, which strictly means *if it please you*, *it* being subject and *you* object.

Auxiliary and Notional Verbs. If we compare the sentences "I have lost sixpence" and "I have sixpence," we see a great difference in the two uses of *have*. In the first sentence it has no meaning of its own, but simply "helps" to form the Present Perfect tense of "lose." In the second sentence, it has a meaning of its own, namely, "I possess." In the first case it is an *Auxiliary* (helping) Verb, in the second a *Notional* Verb (sometimes called *Principal*). The same applies to *shall*, *will*, *may*, *do*, *be*—*e.g.*, "I shall go to-morrow"

(*auxiliary*), and "You *shall* (*i.e.*, must) do it" (*notional*). "I will see you before long" (*auxiliary*), and "I *will* have my own way" (*notional*). "It may be wet to-morrow (*auxiliary*), and "You *may* (*i.e.*, are permitted to), go" (*notional*). "Do you think so?" (*auxiliary*), and "What will you *do?*" (*notional*). "I am coming (*auxiliary*), and "I *am* a man" (*notional*).

Defective Verbs. All the above-mentioned verbs (except *have* and *be*), when used as auxiliaries, are "deficient" in certain tenses. They have no infinitive and no participles (*e.g.*, we cannot say "to shall" or "shalling"), and, therefore, have no compound tenses. Of course, when used as notional verbs, they are not necessarily defective. Thus, "to will" (meaning "to resolve") has all the compound tenses, "I have willed," etc.

1. DO

Infinitive Mood.

Indefinite, (To) do; *Incomplete* (or *Imperfect*), (To) be doing; *Complete* (or *Perfect*), (To) have done.

Participles.

Imperfect, doing; *Perfect*, done;
Compound Perfect, having done.

Indicative Mood.

Past Indefinite.		*Present Indefinite.*	
I did	We did	I do	We do
Thou didst	You did	Thou doest *or* dost	You do
He did	They did	He doeth *or* doth *or* does	They do

When used as a notional verb, *do* is conjugated in full; but when as an auxiliary, only the present and past indefinite are used (*do* and *did*). *Doest* and *doeth* are only used in the notional sense—*e.g.*, "*Doest* thou well to be angry?"

In such phrases as "That will *do*," "How does this *do?*" the *do* is quite a different verb, meaning "to suit, to avail" (from Anglo-Saxon *dugan*). We ought not to use *did* as the past tense of this *do*, though we are constantly using phrases like "I was anxious to see how it *did*."

2. WILL

Indicative Mood.

Past Indefinite.

I would	We would
Thou wouldst	You would
He would	They would

Present Indefinite.

I will	We will
Thou wilt *or* willest*	You will
He will, willeth*, *or* wills*	They will

Subjunctive Mood.

Past Indefinite, I would, etc. (same as Past Indicative).

(No Present Tense.)

* The forms *willest, willeth*, and *wills* are not used when the verb is an auxiliary. When *will* means "to exercise the will," or "to bequeath by will," it has a full conjugation—*e.g.*, "This property *was willed* to me by my uncle," "It is not of him that *willeth*, nor of him that runneth," etc. (Romans).

The past indicative *would* is used as an auxiliary only in reported (or indirect) speech, to take the place of *will* in direct speech—*e.g.*, "He *will* come soon" (*direct*); "He said that he *would* come soon" (*indirect*).

Will is also used to express a customary or frequently repeated action—as: "He *will* play for hours," "When he was young, he *would* spend whole days in the fields and hedgerows."

Won't comes from *wol*, an old form of *will*.

When *will* is an auxiliary verb, it has no infinitive, no imperative, and no participles (consequently, no compound tenses).

3. SHALL

Indicative Mood.

Past Indefinite.

I should	We should
Thou shouldst	You should
He should	They should

Present Indefinite.

I shall	We shall
Thou shalt	You shall
He shall	They shall

Subjunctive Mood.

Past Indefinite.

I should	We should
Thou shouldest *or* shouldst	You should
He should	They should

Present Indefinite.

(None.)

No Infinitive, Imperative, or Participles, whether used as auxiliary or as notional verb.

The past indicative *should* is used as an auxiliary only in reported speech, representing *shall* in direct speech.

Shall comes from Anglo-Saxon *sculan* = to owe, and hence arose the meaning of obligation—as: "He *shall* do it," "You *should* answer when your mother speaks." When *shall* retains this idea of "obligation" it is a notional verb; used as an auxiliary, it loses this force.

Both *shall* and *will* are followed by the infinitive without *to*—as: "He *will* not *come*."

4. MAY

Indicative Mood.

Past Indefinite.

I might	We might
Thou mightest	You might
He might	They might

Present Indefinite.

I may	We may
Thou mayest *or* mayst	You may
He may	They may

Subjunctive Mood.

(Same as Indicative.)

Might gets the *g* from the Anglo-Saxon form of *may*, which was *maeg* (German, *mögen*).

May has no infinitive, imperative, or participles; and in its indicative mood it is never

auxiliary, but always notional—*e.g.*, "You may go" (*i.e*, "You are permitted to go"), "The fish might be seen rising at any hour almost" (*i.e.*, it was possible to see them). In the subjunctive mood, of course, it can be an auxiliary—*e.g.*, "We eat in order that we may live," "May it be so," "I am come that they might have life."

[There is a totally distinct verb "to may," meaning "to gather may-blossom." This verb is fully conjugated in the active voice, as "O that we two were maying." Being intransitive, it has no passive.]

We have now discussed all the auxiliary verbs, namely, *be*, *have*, *do*, *will*, *shall*, and *may*. The following three verbs, *can*, *must*, and *ought*, are sometimes called auxiliaries; but they do not help to form any tense, mood, or voice of any verb.

5. CAN

Indicative Mood.

Past Indefinite.

I could	We could
Thou couldest *or* couldst	You could
He could	They could

Present Indefinite.

I can	We can
Thou canst	You can
He can	They can

Subjunctive Mood.

Past Indefinite.	*Present Indefinite.*
(Same as Indicative.)	(None.)

No Infinitive, Imperative, or Participles.

Can is from an old verb *cunnan*, meaning "to know" (German, *können*). "I can read" therefore really means "I know how to read"—*e.g.*, *Lycidas*, "He knew to sing." We have this meaning still preserved in "to con," and in the Scotch "to ken." "Cunning" is the old imperfect participle of this verb, and *couth* the past participle (*cf. uncouth*, which means *unknown* and therefore *strange*).

As *can* originally meant "to know," it required no infinitive—*cf. Hamlet*, "They *can* well on horseback"; *Lay of the Last Minstrel*, "Other prayer *can* I none." Bacon even has "not to *can*."

The *l* of *could* does not belong to the verb; it was inserted owing to a false analogy with *should* and *would*. It should strictly be spelt *coud*.

Can is always a notional or principal verb—*e.g.*, "I *can* write" (*i.e.*, "I am able to write"); "I would if I *could*" (*i.e.*, "I would if I were able"). To call such sentences examples of the "Potential Mood" is absurd; in the first sentence *can* is a simple indicative, and in the second, *could* is a simple subjunctive.

[*To can*, meaning "to put into a can," is, of course, quite regular.]

6. MUST

Like *can*, this is always a notional verb. It has no inflexions for tense or person, all the persons of each number of each of the two indicative tenses being alike *must*. It has no subjunctive, infinitive, imperative, or participles.

The old form of the present indicative was: I *mot*, Thou *most*, He *mot*, which shows that the *s* does not strictly belong to the first and third persons singular.

The past indicative *must* is used only in reported speech—*e.g.*, "I *must* go" (direct speech, present tense), "He said that he *must* go" (indirect, past tense, meaning "that he *was* obliged to go").

7. OUGHT

Ought is the past indefinite tense of *owe*. Thus, in Shakespeare's "King Henry IV." the hostess says, "He said this other day you *ought* (= owed) him a thousand pounds." It is now used as a present, in the sense of moral obligation, as "I *ought* to be a better man."

With both *must* and *ought*, to express a past tense the verb following requires to be in the perfect infinitive, as "I *ought* to *have done* it at the time," "You *must have enjoyed* your trip."

Owe originally meant *to own*, *to possess*, as "This is no mortal business, nor no sound that the earth *owes*" ("Tempest"); "I am not worthy of the wealth I *owe*" ("All's Well"). and the modern adjective *own* is the past participle of this verb ("Give me back my *own* money" means "Give me back the money you possess for me").

Owe, "to be in debt," is quite regular: *I owed*, *I shall owe*, etc

8. DARE (*to venture*)

The third person singular of the present indicative is properly "he dare," *not* "he dares." The reason is that "I dare" is an old *past* tense, and is not really a present at all—*e.g.*, "Mine unworthiness, that *dare* not offer, etc." ("Tempest"). We now use "I durst" as the past tense of *dare*, followed by the infinitive without *to*, as "He durst not do it." When *dare* is a transitive verb meaning "to challenge," it is perfectly regular (past tense *dared*, as "She dared him to come on").

9. NEED

When *to need* means "to lack, to be in want of," it is perfectly regular. But when it means "to be under the necessity of doing a thing," the third person singular present indicative is often "he *need*," not "he *needs*," as, "He need not go just yet." Contrast this with "He *needs* brains"—*i.e.*, "he lacks brains." Note that *needs* in sentences like "Such things must needs be" is an adverb. In the Authorised Version of the Bible the usual form of the third person singular present indicative is *needeth*.

10. WIT (*to know*)

Indicative Mood.

Past Indefinite.

I wist	We wist
Thou wist	You wist
He wist	They wist

Present Indefinite.

I wot	We wot
Thou wottest *or* wost	You wot
He wotteth *or* wot	They wot

PRESENT INFINITIVE—To wit.

PRESENT PARTICIPLE—Witting *or* wotting (*cf. unwitting*, Milton *unweeting*).

Examples:

"'Twas I did the thing you wot of" ("Two Gentlemen of Verona").

"My master wotteth not what is with me in the house" (Genesis).

"He that was healed *wist* not who it was" (St. John).

This verb is hardly ever used now, except the infinitive *to wit* in the sense of "namely," "that is to say," representing the Anglo-Saxon gerund *to witanne*.

11. QUOTH

Quoth is the past tense of *cwethan* (= *to say*—note the infinitive termination *an*). It is used only in this tense, and only in the first and third persons singular. It always comes before its subject, as *quoth he*, and is used parenthetically for "said I," "said he." Examples: "*Quoth* the raven, 'Nevermore'," "'To tame your fierce temper,' *quoth* she" (Browning).

12. ME-THINKS

This is not "I think," but "it seems to me," the *me* being dative or indirect object, and *thinks* being third person singular present indicative of *thyncan* = *to seem*. The only forms in use are *me-thinks* and *me-thought*. Milton has the form *him thought*—"Him thought, he by the brook of Cherith stood." In "Richard III.," Act iii. Scene 1, some read "Where it *thinks* best unto your royal self."

13. LISTS

In *me-lists* = *it pleases me*, and *him-listed*, lists is an impersonal verb (*cf.* "when and where *likes* [pleases] me best"—"Paradise Regained"). *List* is also used personally, as "The wind bloweth where it *listeth*," "Whithersoever the governor *listeth*."

14. WORTH

This verb is used only in the third singular present subjunctive, expressing a wish, as, "Woe *worth* the day" = "May woe befall the day" (*day* being indirect object or dative). It is from the old verb *weorthan* = to become (German, *werden*).

15. HIGHT

Hight means "was called," "was named." It is from an old verb *hatan*, "to be named" (German, *heissen*)—*e.g.*, "That shallow vassal... *hight* Costard" ("Love's Labour Lost").

16. DIGHT

This is past participle of *dihtan* = to deck, to adorn—*e.g.*:

"With their small feet purple-sandal'd
And their arms with bracelets *dight*."

"Who checks at me, to death is *dight*."
(Marmion.)

EXERCISE

Explain every *should* and *would* in the following:

She would often say "Would I were a man! I *should* have been, for then I would have shown the world a lesson it would never forget." I would reply that I should not attempt to argue with her lest she should get angry; but I now often think that I should have done so. For perhaps I should have convinced her that it would not have been so easy. Should I, or should I not, I wonder?

Continued

FRENCH

Continued from page 654

By Louis A. Barbé, B.A.

THE NOUN

Gender.

1. In French there are only two genders, masculine and feminine (*le masculin, le féminin.*) The rules for ascertaining the gender of nouns are based on their meaning or on their ending.

GENDER ACCORDING TO MEANING.

1. MASCULINE.

(*a*) Nouns indicating males are masculine: *le soldat*, the soldier; *le marin*, the sailor; *le capitaine*, the captain; *le laboureur*, the husbandman.

Exceptions are: *une connaissance*, an acquaintance; *une dupe*, a dupe; *une personne*, a person; *une victime*, a victim; and some military terms, such as: *une sentinelle*, a sentry; *une recrue*, a recruit, which are feminine.

(*b*) The names of the days of the week, of the months, and of the seasons are masculine. They are:

dimanche, Sunday.	*mercredi*, Wednesday.
lundi, Monday.	*jeudi*, Thursday.
mardi, Tuesday.	*vendredi*, Friday.
samedi, Saturday.	

janvier, January.	*juillet*, July.
février, February.	*août*, August.
mars, March.	*septembre*, September.
avril, April.	*octobre*, October.
mai, May.	*novembre*, November.
juin, June.	*décembre*, December.
printemps, spring.	*automne*, autumn.
été, summer.	*hiver*, winter.

The mid-month is formed by prefixing *mi-*, and in that case the noun becomes feminine: *la mi-janvier, la mi-août.*

(*c*) The names of trees and shrubs are masculine: *le chêne*, the oak; *le hêtre*, the beech; *le pommier*, the apple-tree; *le rosier*, the rose-bush.

Exceptions are: *une aubépine*, a hawthorn; *la bruyère*, heather; *la bourdaine*, the black alder; *une hièble*, a dwarf elder; *la ronce*, the briar; *la vigne*, the vine; *une yeuse*, an evergreen oak all of which are feminine.

(*d*) The names of metals, minerals, gases, and chemical substances are masculine: *le fer*, iron: *le mercure*, mercury; *l'oxygène*, oxygen; *le nitrate*, nitrate; *l'étain*, zinc; *le manganèse*, manganese; *le jais*, jet.

Exceptions are: *l'argile*, clay; *l'agate*, agate; *la craie*, chalk; *la houille*, sea-coal; *la chaux*, lime.

(*e*) The names of colours are masculine: *le rouge*, red; *le bleu*, blue; *le blanc*, white.

An exception is *la sépia*, sepia—*e.g.*, *un dessin à la sépia*, a sepia drawing.

(*f*) Names of languages are masculine: *le français*, French; *l'anglais*, English.

(*g*) Names of weights and measures (in the decimal system) are masculine: *le mètre*, *le litre*.

Exceptions: Some of the old names that are occasionally used, particularly for the literal translation of English weights and measures, are feminine:

une aune, an ell.	*une livre*, a pound.
une brasse, a fathom.	*une once*, an ounce.
une coudée, a cubit.	*une pinte*, a pint.
une lieue, a league.	*une quarte*, a quart.

(*h*) The points of the compass are masculine:

le nord, north.	*l'est*, east.
le sud, south.	*l'ouest*, west.

(*i*) The names of mountains are masculine, except in some plural forms, as: *les Alpes*, *les Pyrénées*, *les Vosges*, *les Cévennes*, which are feminine.

(*j*) All words belonging to other parts of speech are masculine when used as nouns: *le sublime*, *un sixième* (one-sixth), *le manger et le boire* (eating and drinking), *les mais et les si* (but's and if's).

2. Feminine.

(*a*) Nouns indicating females are feminine: *la mère*, the mother; *la sœur*, the sister.

Exceptions: The following nouns remain masculine even when applied to women:

un amateur, a lover or fancier (of animals, art, etc.).	*un peintre*, a painter.
	un philosophe, a philosopher.
un ange, an angel.	*un possesseur*, a possessor.
un artisan, an artisan.	
un auteur, an author.	*un poète*, a poet.
un censeur, a censor.	*un professeur*, a professor.
un chef, a chief.	
le défenseur, the defender.	*un sauveur*, a saviour.
	le successeur, the successor.
un docteur, a doctor.	
l'écrivain, the writer.	*le témoin*, the witness.
l'imposteur, the impostor.	*un traducteur*, a translator.
un partisan, a partisan.	*un tyran*, a tyrant.

(*b*) Abstract nouns, the names of arts, science, professions, virtues, and vices, are feminine:

la sagesse, wisdom.	*la chimie*, chemistry.
la peinture, painting.	*la charité*, charity.
la poésie, poetry.	*l'avarice*, avarice.

The following, all of which are masculine, are exceptions to this rule:

le courage, courage	*l'orgueil*, pride.
le dessin, drawing.	*le péché*, sin.
le jeu, gambling.	*le plaisir*, pleasure.
le mensonge, lying.	*le vice*, vice.
le mérite, merit.	*le zèle*, zeal.

Note. The gender of most words included in both the rule and the exceptions can also be determined by their endings.

(*c*) The names of diseases and ailments are feminine: *la toux*, cough; *la fièvre*, fever; *la rougeole*, measles; *la petite vérole*, small-pox; *une migraine*, headache; *la coqueluche*, whooping-cough; *la grippe*, influenza; *la goutte*, gout.

Exceptions are: *le choléra*, cholera; *un rhume*, a cold; *le rhumatisme*, rheumatism; *le typhus*, typhus.

(*d*) The names of fruits are feminine: *la pomme*, the apple; *la cerise*, the cherry; *la prune*, the plum; *la poire*, the pear.

Exceptions are: *un ananas*, a pineapple; *le brugnon*, the nectarine; *un abricot*, an apricot; *un coing*, a quince; *un citron*, a lemon; *des cassis*, black-currants; *un raisin*, a grape, all these being masculine.

(*e*) The names of festivals and saints' days are feminine, even when the saint's name is masculine: *La Toussaint*, All Saints' Day; *La Saint-Michel*, Michaelmas.

An exception is *le Noël*, Christmas.

Gender according to Termination.

1. Masculine.

(*a*) Nouns ending in *b*, *c*, *d*, *g*, l, *p*, *q*, or *z* are all masculine:

le plomb, lead.	*le baril*, the barrel.
le bac, the ferry.	*le coup*, the blow.
le bord, the edge.	*le coq*, the cock.
le rang, the rank.	*le nez*, the nose.

(*b*) F is a masculine ending, except in *la clef*, the key; *la nef*, the nave; *la soif*, thirst.

(*c*) M is a masculine ending, except in *la faim*, hunger, and the place name *Jérusalem*.

(*d*) N is a masculine ending except in *la fin*, the end; *la main*, the hand.

(*e*) R is a masculine ending, except in *la chair*, flesh; *la cour*, court, courtyard; *la cuiller*, spoon; *la mer*, sea; *la tour*, the tower.

(*f*) S is a masculine ending, except in *la brebis*, sheep (ewe); *la fois*, time (as in *une fois*, once = one time); *la souris*, mouse; *la vis*, screw.

(*g*) T is a masculine ending, except in *la dent*, tooth; *la dot*, dowry; *la forêt*, forest; *la gent*, race; *la hart*, halter; *la nuit*, night; *la part*, share. *Jument*, mare, is the only word ending in *ment* that is feminine.

(*h*) X is a masculine termination, except in *la chaux*, lime; *la croix*, cross; *la faux*, scythe; *la noix*, walnut; *la paix*, peace; *la perdrix*, partridge; *la poix*, pitch; *la toux*, cough.

(*i*) A is a masculine ending, except in some names of dances, as *la polka*, polka.

(*j*) E (not preceded by *t*) is a masculine ending, as *le thé*, *le café*.

(*k*) I is a masculine ending, except in *la fourmi*, ant; *la merci*, mercy; *une après-midi*, afternoon.

(*l*) O, which only occurs as final in *l'écho*, echo, is a masculine ending.

(*m*) U and *ou* are masculine endings, except in *la bru*, daughter-in-law; *la glu*, birdlime; *la tribu*, tribe; *la vertu*, virtue.

(*n*) *Eau* is a masculine ending, except in two words, *l'eau*, water; *la peau*, skin.

(*o*) *Oi* is a masculine ending, except in *la foi*, faith; *la loi*, law; *la paroi*, partition wall.

(*p*) Nouns ending in *acle* and *ocle* are masculine, except *la débâcle*, breaking-up of the ice, and, figuratively, downfall.

(*q*) Nouns ending in *age*, *ège* and *ige* are masculine, except *la cage*, cage; *la nage*, swimming; *la plage*, shore; *la rage*, rage and rabies; *la page*, page (of a book); *une image*, image; *une allège*, a lighter; *la tige*, stalk.

(*r*) Nouns in *aume* are masculine, except *la paume*, palm (of the hand), tennis.

(*s*) Nouns in *aire* are masculine, except *une affaire*, affair; *la circulaire*, circular; *la chaire*, pulpit; *la paire*, pair; *aire*, area.

(*t*) Nouns in *asme* and *isme* are all masculine.

(*u*) Nouns in *âtre*, *itre*, *iste* and *ogue* are masculine, except *la marâtre*, stepmother; *une huitre*, oyster; *la vitre*, window-pane; *la piste*, track; *la vogue*, vogue; *une églogue*, eclogue.

2. Feminine.

(*a*) Nouns ending in mute *e* preceded by *é* are feminine, except a few proper names, such as *Amédée*, *Persée*, and words in which *ée* represents *eum*, as *la musée*, museum; *la Colisée*, Colosseum.

(*b*) Nouns ending in mute *e* preceded by *i* or *u* are feminine, except *le génie*, genius; *un incendie*, fire; *le parapluie*, umbrella.

(*c*) Nouns ending in mute *e* preceded by a double consonant are mostly feminine. The chief exceptions are *le beurre*, butter; *le lierre*, ivy; *le parterre*, flower-bed, also pit (in a theatre); *le tonnerre*, thunder.

(*d*) Nouns in *ade* and *ude* are feminine, except *le grade*, grade, degree; *le camarade*, comrade; *un interlude*, *le prélude*.

(*e*) Nouns in *ure* are feminine, except *un augure*, augury; *le murmure*, murmur; *le parjure*, perjury and perjurer; and words belonging to the terminology of chemistry, as *le cyanure*, cyanide.

(*f*) All nouns in *aille* and *ouille* are feminine.

(*g*) All nouns in *ette* are feminine, except *le squelette*, skeleton.

(*h*) All nouns in *ance*, *ense*, and *ence* are feminine, except *le silence*.

(*i*) Nouns in *té* are feminine, except *le côté*, side; *le comité*, committee; *le comté*, county; *été*, summer; *en pâté*, a pasty; *un traité*, a treaty, also treatise; and a few more not of frequent use.

(*j*) All nouns in *tion* are feminine, with the one exception of *le bastion*, bastion.

(*k*) Nouns in *aison* are feminine.

(*l*) All abstract nouns in *eur* are feminine, except *l'honneur*, honour; *le labeur*, toil; *le bonheur*, happiness; *le malheur*, misfortune.

Double Gender.

Some words that are spelt alike differ in meaning according as they are masculine or feminine. Of such words the following occur frequently:

le crêpe, crape.	*le mode*, mood.
la crêpe, pancake.	*la mode*, fashion.
le livre, book.	*le mousse*, ship-boy.
la livre, pound.	*la mousse*, moss.
le manche, handle.	*le page*, page (boy).
la manche, sleeve,	*la page*, page (of a book).
le mémoire, memorandum.	*le pendule*, pendulum.
la mémoire, memory.	*la pendule*, timepiece.
le poêle, stove, pall.	*la tour*, tower.
la poêle, frying-pan.	*le vase*, vase.
le poste, post, station.	*la vase*, ooze, mud.
la poste, post-office.	*le vapeur*, steamboat.
le somme, nap.	*la vapeur*, steam.
la somme, sum.	*le voile*, veil.
le tour, turn, trick, tour.	*la voile*, sail.

Exercise V.

Vocabulary.

année (f.), year. (*a-ney*)
arbre (m.), tree. (*ar-br*)
arbrisseau (m.), shrub. (*ar-brĕĕs-sō*)
fleur (f.), flower. (*flĕr*)
fruit (m.), fruit. (*frü-ĕĕ*)
leçon (f.), lesson. (*lĕh-song*)
mois (m.), month. (*mwah*)
neige (f.), snow. (*nayj*)
saison (f.), season. (*say-zong*)
derrière, behind. (*dĕr-rĕĕ-err*)
premier (m.), first. (*prĕ-mĕĕ-ey*)
première (f), first. (*prĕ-mĕĕ-err*)
quatre, four. (*kăhtr*)

1. There are four seasons: [the] spring, [the] summer, [the] autumn, and [the] winter. 2. Spring is the first season of the year. 3. Winter is not the season of [the] flowers. 4. In (*en*) summer there is no snow. 5. The month of December is one of the months of winter. 6. The apple is the fruit of the apple-tree. 7. The briar has no fruit. 8. The oak is a tree, [the] heather is a shrub. 9. There are a beech and a hawthorn behind the house. 10. He has a plum, she has an apricot, and we have some cherries. 11. There is a bird in the cage. 12. The children are on the shore. 13. The brother and sister have the measles. 14. I have a headache. 15. Lying is a vice. 16. The sentry is not a recruit. 17. There is a picture on the first page of the book. 18. I write with chalk. 19. The sailor and the cabin-boy love (*aiment*) the sea. 20. The end of the lesson.

KEY TO EXERCISE IV.

1. Le papier du livre. 2. Le héros de l'histoire. 3. Le haut de la maison. 4. Le crayon de l'enfant. 5. Voilà la plume. 6. Voilà la règle. 7. L'encre est dans l'encrier. 8. L'encrier est sur la table. 9. Il y a un encrier sur la table. 10. La hauteur de la maison. 11. Il y a un livre, un encrier, un buvard, une règle et un cahier sur la table. 12. De la chaise à la table. 13. Le père et la mère sont dans la maison. 14. La charité est une vertu. 15. Le fer est un métal. 16. L'homme a un frère et une sœur. 17. Les enfants ont des grammaires. 18. Voilà le livre d'un des enfants. 19. J'ai parlé aux enfants de la femme. 20. J'écris au frère et à la sœur. 21. J'ai des crayons. 22. Elle n'a pas d'encre. 23. Vous avez besoin de plumes et de papier. 24. Il a de bons livres. 25. Vous avez des crayons et du papier; nous n'en avons pas. 26. Vous avez de bonnes plumes. 27. Le père de l'enfant a une maison. 28. Voilà le père de l'enfant. 29. Elle a besoin d'encre et de papier. 30. L'or et l'argent sont utiles aux hommes. 31. Les enfants n'ont pas de patience. 32. La patience est une vertu.

Continued

The Working Scale. Schedule of Sizes. Disproportionate Figures. Coat Drafting.

A DOUBLE-BREASTED COAT

Block Patterns. A pattern cut precisely as explained and illustrated in the last lesson (see page 793) will be found a valuable guide, and a model by which other shapes may be cut; in fact, many cutters in practice prefer to use block patterns as against drafting fancy styles of coats by system. The custom is to produce them in stout cardboard, having the suppressions only partly cut to preserve strength. The position of the breast and waist-lines, and also the sleeve pitches, are indicated by notches, and in many instances they have the measures printed on them.

The Working Scale. From the instruction already given it will be gathered that many of the essential points are found by a division of the "Scale," and failing further explanation one might well assume that in all sizes the scale is found by halving the chest. But this is not the case, owing to the fact that development is not equal at all stages of life.

The child is big in shoulders, neck, arms, and waist, relatively speaking, whereas adults who are inclined to stoutness are decidedly small in shoulders, etc., as compared with the ideal woman of 36 chest; consequently, these peculiarities must be met by enlarging the scale for small sizes, and reducing it for those above 36 chest. The method is as follows:

For figures above 36-in. chest measurement, deduct ¼ for every size over 36, and halve the result to find the scale. Thus we will take a very extreme size for an example: 48 chest is 12 in. larger than 36; deduct 12 quarters (3 in.) from the chest, and so obtain 45, half of which gives us the working scale of 22½ in.

For sizes below the normal add ¼ in. for every inch under 36. Thus, taking the girl's 24 chest as example: 24 is 12 in. under, and 12 quarters (3 in.) added to 24 gives 27, half of which is the scale, viz., 13½ in.

Alteration to scale is absolutely imperative if our system is to meet the needs of all figures of average build, and those methods which will not stand the test of comparative size drafting or checking are extremely dangerous in the hands of the inexperienced cutter.

Diagram 18 shows the three sizes compared. The dot and dash lines indicate the scye of the 48 chest, while the dash lines show the 36. It will be noted that there is not the same increase in height of back neck on the large size relative to other parts, and this is rendered necessary by the upright carriage of most stout figures. They need a short back balance, and this is brought about by lowering the back neck from * to A ⅛ for every 2 in. over the 36 size. Consequently, for a 48 chest * to A would be made ¾ in. A to B would then be made 2 in., and from * to O one-third of scale, plus 2 in. as before explained.

At first the subject of finding the scale may appear a little intricate, but it is a lesson which, when once learnt, enables one to cope with all sizes.

Schedule of Sizes. The sizes here shown are compiled from actual experience, and will be found, if used in conjunction with the system, to produce garments which will fit most figures of the stated size breast measurements. It will prove also a valuable help to those who recognise the importance of drafting various sizes in order to grasp the principle of the system thoroughly. It is self-explanatory, therefore we will not dwell upon it, except to say that if a ¼ in. or ½ in. is added to the scale the result will be that slight ease is given to the shoulders, hence there is no necessity of treating with so small a fraction as a quarter of an inch.

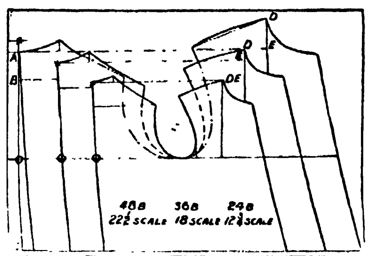
SCHEDULE OF SIZES FOR DRAFTING LADIES' COATS

	For Girls				For Women									
Sizes	1	3	5	7	1	2	3	4	5	6	7	8	9	10
Breast	22	24	26	28	30	32	34	36	38	40	42	44	46	48
Waist	22	22	22½	22½	23	22½	23	24	26	27	28	30	32	34
Seat	26	29	32	34	36	38	39	40	42	44	46	48	50	54
Nape to Waist ..	12½	12½	13	13½	14	14½	15	15½	16	16	16	16	16	16
Across Back ..	4¾	4¾	4¾	5	5¼	5½	5¾	6	6½	6¾	7	7¼	7½	7¾
Sleeve Length ..	19	21	23½	25	27	27½	28	29	30	30	30	30	30	30
Half Neck	5½	5¾	6	6½	6¾	7	7¼	7¼	7¾	8	8¼	8½	8¾	9
Working Scale ..	12¾	13½	14¼	15	15¾	16½	17½	18	18¾	19½	20¼	21	21½	22½

It should also be pointed out that the size numbers indicated at the top should be used with care, as many firms number their sizes according to the ranges of shapes stocked; hence there is great variation.

Extra Allowances. The system provides ¼ in. sewings at all parts. In some instances it will be necessary to provide a larger quantity for turnings, such as to meet the requirements of a serge that ravels easily, when, instead of chalking by the edge of pattern previous to cutting the cloth, it must be marked ¼ in. away, and thus provide ½ in. turnings.

Additions are also made for turn-ups at sleeve ends (2 in.), at bottom of coat (1½ in.); and in most cases extra cloth is left down side seams (1 in.) and under arm-seams (1 in.). Inlays are also left round the front shoulder and top of back neck, as a general rule, but in every case these additions are made when planning the pattern upon the cloth (see Cutting Cloth) and are rarely embodied in paper patterns.



18. COMPARATIVE SIZES

The question of allowing for seams often troubles the beginner, and we have known many to add seams round the scye and front shoulder, which, as far as depth or length is concerned, of course, is not needed, for if a seam is taken off at all parts, the size of shoulders, including depth of scye (0 to 8), will remain precisely as cut — a seam off the shoulder and neck is compensated for by a seam from the scye base.

Children's Garments. For juvenile garments increase the size of inlays, or what are more appropriately termed "outlets," to enable quickness of growth — especially in height—to be coped with.

Disproportionate Figures. The common forms of disproportion met with—the majority of figures vary more or less from "stock" measures—may be summarised as follows: Stooping and erect figures, and long and short necks.

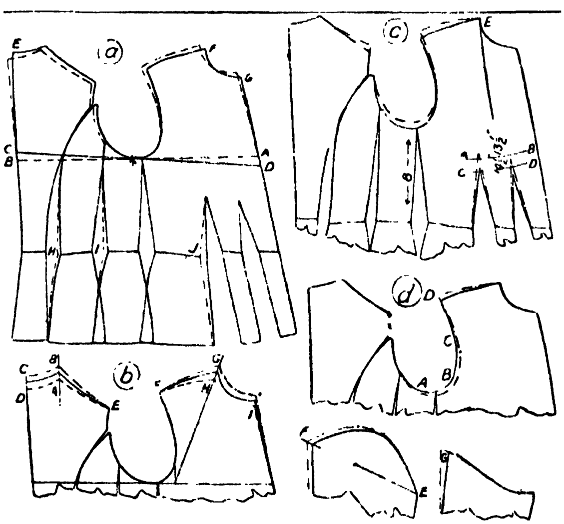
A stoop is often accompanied by large waist and flat chest, and is generally classed as "poor," while the erect attitude is usually associated with small waist, large breast, and backward carriage, and described as "good."

Variety in length of neck is purely a local deformation, and may be found to exist in greater or less degree on all figures, in a similar manner as will long arms, extra long waist, high hipbones, etc., be met with. It will be seen that here is ample scope for the practice of observation; for, while the measures provide for some of these peculiarities, they do not cover all, and special adaptations must be made to meet them.

Diagram *a* [19] shows the alteration (marked in solid lines) from the normal cut pattern (dotted lines) to meet the requirements of a stooping figure. The breast-line, indicated by dashes, should be swung down from A to D and up from B to C, pivoting at *. The quantity of rise of back and fall of front must be consistent with one's view of the particular figure to be fitted. Generally ½ in. to ¾ in. is sufficient variation.

It will be seen that the back is lengthened at E, while the front is shortened at F and G. For prominent shoulder-blades take more out at H and I, and fill up J accordingly, on account of the usual flatness of chest. The reverse alteration will be needed for an erect figure.

For long or short necks draw a perpendicular line from A through point, and add or deduct ½ in. or so, according to one's estimation of the extent of deformity [19*b*].



19. CUTTING FOR DISPROPORTIONATE FIGURES

Treat the front by ruling from front of scye through neck point, and alter as shown; quantities to agree with those used on the back. Keep E and F stationary, and advance or recede J I, as shown in the diagram.

If the side length has been taken, apply such measure up from waist to base of scye, and pass the block pattern up or down to meet the measure taken. (See dot and dash lines.)

We also show the checking of the height of darts [19*c*]. Place the back neck measure on E, and sweep A B the length to breast plus ½ in. Place top of front dart ½ in. below the sweep, and the back dart ½ in. above it. A B agrees with a 13-in measure, while C D is for a low type measuring 14 in. The waist level can also be varied similarly.

To cut a very easy scye, deepen it at A ¼ in., at B ½ in., and at C ¼ in. Also add ½ in. at D, and ¾ in. to the sleeve at F and G [19*d*].

A Double-breasted Coat. In picture 20 we have a double-breasted jacket fastening with three buttons, bold revers rolling low, front cut with vertical breast seam, back whole with side-seams to scye, and the body made semi-fitting.

Take size 4 as sample measures for practice.

Rule line 0 to 30 to the desired length of garment; 0 to 2 two inches, and to 5 three in. below point 2; 0 to 8 one-third of scale plus 2 in.; 0 to 15½, the waist length; to 22½, the hips at 7 in. down.

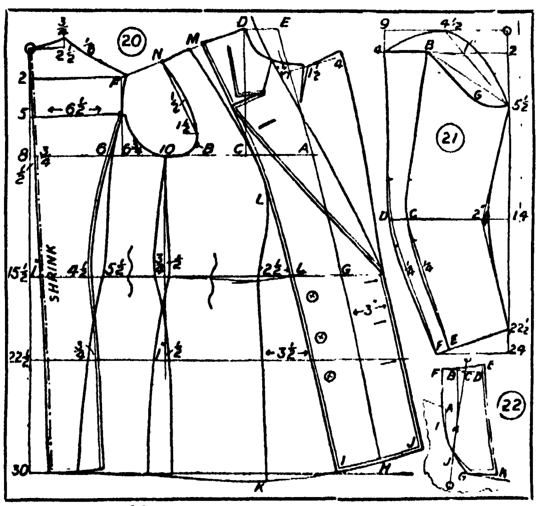
Square lines out as shown. Go in 1 in. at 15½, and rule through from 0 to bottom.

0 to 2½, one-sixth scale, less ½ in. Shape back neck as shown. Apply back width, adding ½ in., and square the line up at back scye. Spring out ¼ in. beyond point F. Shape back shoulder.

From ½ to A, half-chest, plus 2 in. Go back A to B half-scale less, ½ in. Place C ¾ in. back from the centre of A B and square up half-scale 9 in. to D. Rule D to F for shoulder slope.

Square out from D to E one-sixth scale, less ½ in., and draw through from E to G and H, for true centre line. D to N 1¼ in. more than back shoulder seam from ¾ to F. D to M 3 in., or to taste. Take out 1 in. at M. For flat bust close M, and for extra prominence open it more than the quantity stated. Rule from N to point 1½, and shape the scye as shown.

Go down 3 in. from E, and square out 4 in. for a moderately heavy revers. Raise ½ in. at 4, also mark the vee at 1½ in. from centre line and cut in the direction shown.



20-22. A DOUBLE-BREASTED COAT

Beyond G and H add 3 in. for the overlap.

Position of Seams. The width of back at waist is largely a matter of taste. First cut off ¼ in. from back line as per dot and dash line, owing to there being no seam in the centre; then, assuming we want the whole back at waist to make up 6 in., mark from crease edge line to point 4½, 3¼ in.—that is, half the width plus one seam.

Mark the back section ½ in. wider at the hip line, and carefully shape the seam to agree with the diagram. Take out one inch at 4½—5½, and overlap the side piece ¾ in. at the seat. Continue the run of seam to the sleeve pitch, opening it ¼ in. at point 6.

From G to L, one-sixth of scale plus ½ in. Draw L to I parallel to G H. Take out one-sixth of scale less ½ in. at L, and one-sixth plus ½ in. at hip line. Shape the seam, placing most importance on the line of front.

It will be noticed that the seam runs at halfway between B and A, or ¾ in. in front of C; but this position is by no means fixed. Close suppression at L at 2½ in. down from C, and drop ½ in. at K. Sweep from K forward by C and so find I; and from I to J by point A, which operation will be found to produce a level run of bottom.

For the under-arm seam go back 2½ in. from B, and square down. Take out ½ in. at front and ¾ in. at back as shown. The half-hip measure plus 1½ in. is made up at side.

The sleeve draft [21] is practically the same as No 17, but in this case it will be seen that the back pitch is about 1 in. lower, consequently from 5½ to 2 is that quantity less than in No. 21. Further, owing to the extra width of top half, it is preferred to make the hind-arm variation shown on diagram 21, which consists of making from 2 to D one-third of scale plus one inch, and placing C at 1 in. back from D. The position of the seam is also changed; at the cuff from 22½ to F is made one-third of scale less ½ in., and E is placed 1 inch in. The alteration has the effect of bringing the seam further under the arm. When basting the under-arm seams, ease on the top half D to C, or the balance of sleeve will be disturbed.

Cutting the Collar. Having cut the front section, lay the neck portion upon another sheet of paper in order to draft the collar [22].

Line O O represents the break line, or crease of lapel, drawn from a point 1 in. out from hollow of gorge to the desired length of opening. From the neck point A measure up to point C 2½ in., or ¼ in. more than the width of back neck. Square D F through C by O O.

The average height of collar-stand is 1¼ in., and depth of fall 2 in., consequently the difference between stand and fall is ¾ in., and this is used to find the distance from C to B. Hard line B * represents the top crease of collar. B to F the stand; B to D the fall; D to E the difference, ¾ in.

Shape outline as shown, keeping to the gorge from I to J, and giving ¼ in. opening, or overlap, at G. The position of H is entirely a matter of taste, depending upon the quantity of opening desired between collar-end and point of rever.

The * represents the point where the crease leaves the line O O.

Cut out the pattern so that there are seven parts—viz., front, side front, under-arm piece, back, the top sleeve, the under-sleeve, and the collar.

The Theory of Bessemer Steel Production. The Bessemer Converter and its Operation. Modifications of the Process.

MAKING BESSEMER STEEL

In the Bessemer steel process—forcing air through molten pig iron in numerous small jets—the silicon and carbon become rapidly oxidised, and produce sufficient heat to maintain the iron in the liquid state until it is completely purified. Two different modes of working are adopted, according to the nature of the pig iron and of the lining of the vessel. These are termed the *acid* and *basic* processes respectively. Sir Henry Bessemer's great invention is not confined to blowing air through molten pig iron, but includes numerous mechanical appliances invented by him for carrying out the process, as well as the shape and construction of the converter. The original vessel was fixed with air inlets at the side, but this was soon replaced by a tipping converter, supported on trunnions, the air being injected at the bottom. After trying various patterns, he adopted the pear-shaped vessel now commonly employed. The inventor perceived the great advantage of conserving the great heat of the ingots by covering them, when stripped, with hot sand, from which the still red-hot ingots were carried to the rolls. This was the first crude idea of soaking-pits, afterwards so successfully applied by Gjers.

Acid Process. In the acid process, the iron employed is a grey hæmatite pig, rich in silicon and very low in phosphorus. It is generally melted in a cupola and run into the converter when in the horizontal position. The blast is turned on and the vessel rotated into the vertical position. In the first stage the graphite is changed into combined carbon, and silicon is oxidised, forming a slag with oxides of iron and manganese. In the second stage the carbon is oxidised to carbonic oxide, the evolution of which causes a violent action, with the ejection of showers of sparks and a brilliant flame. As soon as the carbon is removed the flame drops and the blow is stopped. About 10 per cent. of spiegeleisen or its equivalent of ferro-manganese is then added, and imparts the necessary carbon, the manganese taking up the oxygen from the iron, thereby forming oxide of manganese, which passes into the slag.

The length of the blow depends on the quality of the pig iron, and chiefly on the silicon and manganese content. It varies in duration from 15 to 30 minutes. The loss of iron in the process varies from 15 to 20 per cent.

The steel is poured into the casting ladle, which rests on the jib of a ladle crane. This crane now swings the ladle successfully over the ingot moulds standing in the casting ring, and the steel is run into the moulds through a nozzle in the bottom of the ladle by raising the internal stopper by means of a lever on the outside.

The ingot moulds are lifted from the partly-solidified ingots by the ingot cranes and by means of tongs, termed *dogs*, hanging from these cranes. The ingots themselves are lifted and carried to the heating furnace in the rolling department.

After discharging the steel, the converter is inverted to tip out the slag, and repaired, if necessary, before running in another charge. The oxide of iron produced by the blast on the ends of the twyers gradually corrodes them, so that the twyers become gradually shorter and the bottom thinner. After 15 to 20 heats the bottom is removed and renewed.

Limitations of the Acid Process. It has already been stated that the acid process is applicable only for pig iron low in phosphorus, but sufficient silicon must be present to yield the necessary heat. The varieties of iron used in this country are those smelted from hæmatite or magnetic ores. Since the purification of the crude metal is effected by the oxygen of the air, it is obvious that the greater fluidity of grey iron is advantageous, as the plastic condition of molten white iron is liable to interfere with the passage of the air through the molten metal. In fact, white iron can be treated only with increased waste, especially as it is deficient in silicon. Moreover, white iron is often much higher in sulphur than grey iron. Also, the carbon being in the combined form, the production of carbonic oxide takes place at too early a stage of the process, and afterwards, the carbonic oxide being present in insufficient quantity, the requisite high temperature is not attained.

The chief essentials, then, in the composition of the pig are a very low percentage of sulphur and phosphorus, with about 2 per cent. of silicon. Both silicon and manganese can be practically removed by the blow, as both elements are oxidised and unite to form a slag. The following analyses give the composition of some Bessemer pigs.

MATERIAL	Carbon.	Silicon.	Manganese.	Phosphorus.	Sulphur.
Charcoal pig	3·90	1·96	3·06	0·04	0·02
Greenwood	3·75	1·76	0·13	0·08	0·14
Snelus ..	3·27	1·95	0·09	0·05	0·14
Staffordshire	3·94	1·61	0·12	0·02	0·03
Jordan ..	4·40	1·81	1·08	0·01	0·04
American ..	3·10	0·98	0·40	0·10	0·06

Howe stated in 1890 that while there are American mills where 2 per cent. or more of silicon is present in the charge, the majority use less than 1·75 per cent., and what appears to be the most characteristically American practice has habitually only 0·66 per cent. to 0·9 per cent. of silicon. In order to blow iron with such little silicon successfully, the heats must follow each

other quickly, and the vessels and ladles must be very hot. He considers that as far as convenience of blowing is concerned, 1·25 per cent. of silicon is the best proportion. Metal with 0·5 per cent. of silicon has been blown in Sweden, but this is done only when the initial temperature is very high. For low silicon, then, quick blowing and short intervals are necessary.

Results of the Acid Process. In the acid process almost all the effective heat comes from the combustion of the silicon, and the greater the percentage of silicon the hotter the charge, the longer the blow, the greater the loss, the more expensive the repairs and maintenance, and, with high silicon, the poorer is the quality of the steel likely to be. If, however, the silicon is too low, it causes cold heats, heavy sculls, and bad working generally. The place of silicon may be taken to some extent by manganese, as in Styria and Sweden, where the cast iron is obtained from spathic ores. In such a case the silica lining is called upon to supply the silica for forming a slag with the oxide of manganese. If the blow be too hot, as indicated by the appearance of the flame, scrap steel is added to lower the temperature. In England, where high silicon irons are used, the aim is to keep the silicon sufficiently low, while in Sweden it is just the reverse. With coke pig, when the silicon is low, the sulphur will probably be too high, causing red-shortness in the steel.

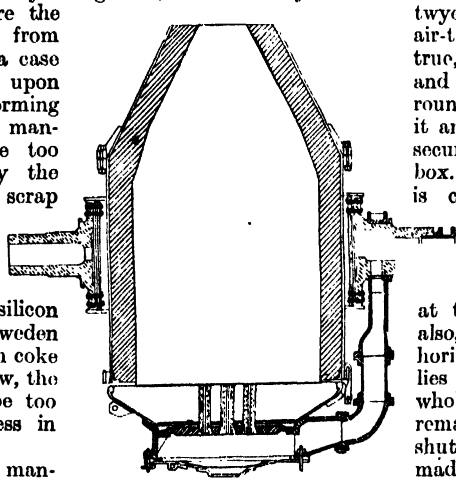
When the amount of manganese in Bessemer pig iron is upward of 2 per cent., as it often is in Sweden, the direct method is adopted—that is, the blow is not continued till the whole of the carbon is burnt off, as in England, but stopped when the metal contains the desired amount of carbon, which is judged by the aid of the spectroscope and the colour of the slag. The amount of manganese left in the steel varies from 0·1 per cent to 0·3 per cent.

The gases escaping at the mouth of the converter indicate that at the beginning of the blow the carbon is largely burnt to carbon dioxide At the end of the blow the gas given off is chiefly nitrogen.

The Converter. The modern converter is built of mild steel or wrought-iron plates riveted together and lined with siliceous or basic material, according as the acid or basic method of working is adopted. We may broadly classify Bessemer converters into *fixed* and *movable*. The former have only a limited application, but the latter are the kind generally employed.

The acid-lined converter is lined internally with silica bricks or with ganister, which may be rammed round a central core. The vessel is supported on trunnions, one of which is hollow and connected with the blast main, through which the air from the blowing engines passes to the wind-box at the bottom of the converter. The body is mounted on an iron ring, to which it and the trunnions are bolted. In the early vessels the entire shell was riveted together, but in the modern vessel the bottom and the nose are detachable from the body. The importance of a movable body will be perceived when it is mentioned that the twyer portion lasts only from 15 to 20 heats, while the body will stand several months' wear. The nose is not often removed except for relining. The centre of the bottom section is the *plug*, in which are fixed the fireclay twyers, each containing 12 to 18 holes, about $\frac{3}{8}$ in. in diameter, through which the air passes to the metal.

The entire bottom is fixed to the body by means of lugs and cottar-pins, and is made easily removable for the examination of faulty twyers, but it must also be air-tight. Hence it is faced true, with a wide bearing, yarn and clay packing being put round the bottom plate between it and the box, the plate being secured by cottars to the blast box. The movable converter is capable of rotation in a vertical plane through an angle of 180° or more, thus enabling the contents to be discharged at the end of the blow; and also, by turning it into a horizontal position, the metal lies out of the blast below the whole of the twyers, and may remain there after the blast is shut off. The converter is made in two forms, known as the concentric and the eccentric forms. The former is shown in 12 and the latter in 13.



12. CONCENTRIC CONVERTER

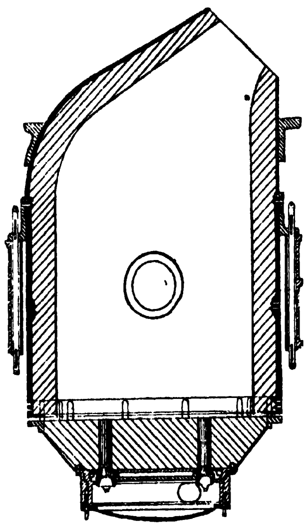
Rotating Mechanism. For the rotation, an iron framework supported on columns carries the converter on suitable bearings, arranged so that the vessel can be rotated on its trunnions. This is effected by means of a pinion, keyed on to one of the trunnions, gearing into a rack attached to the end of a double hydraulic ram. The position of the ram and cylinder may be either vertical or horizontal. Both the rack and pinion and the ram must be securely cased in sheet iron, to prevent injury by splashing of the metal or the slag on them. The valves for the hydraulic cylinder are usually controlled at some distance from the converter from a raised platform known as the *pulpit*. In some cases the rotation is effected by a worm and pinion gear, actuated by a hydraulic engine or by a double or triple cylinder steam-engine. In addition to other advantages, this allows for a complete revolution of the vessel through 360°. However, the simplicity of the rack and pinion arrangement, and the facility with which it may be manipulated, have led to its general adoption.

The bottom of the converter being the portion subjected to the greatest wear, and requiring

to be frequently removed, is made interchangeable, and a number of bottoms are kept in readiness, so that when one gives way it can at once be replaced. This is done by placing a trolley on the table of a hydraulic ram, fixed under each converter, and then, having raised the trolley and uncottered the bottom section, the latter is removed by means of the ram. In fixing a new bottom, it is run on a carriage to the table of the ram, wet ganister and fireclay is placed round the bottom section, and the bottom pressed tightly against the bottom of the converter by the hydraulic ram, and cottered on. In some works, instead of using a hydraulic ram under the converter, the bottom is hoisted into position and pressed home by powerful screw-jacks.

The lining of the Bessemer converter in this country is a siliceous sandstone, which contains from 85 to 90 per cent. of silica, and occurs below the coal measures. This is ground fine, mixed with water, and rammed in between a central wooden core and the shell of the vessel. In America the lining consists of a mixture of 60 per cent. crushed quartz, 25 per cent. fireclay, and the remainder of ground-up firebricks and other siliceous material. The American lining lasts for 400 to 500 heats, while the British lasts double that time; but we must take into account the more rapid working of the American vessels.

Concentric Vessel. In the eccentric vessel [13] a large amount of metal can lie in the belly without running into the twyers or out of the nose, and to some extent it prevents slopping. When the method of using metal direct from the blast furnace was introduced, a modification of the converter appeared necessary, so that it might receive molten pig iron from the blast furnace ladle when turned away from the pit, and receive spiegeleisen from the cupola when turned towards the pit. This is readily done with the concentric, but not with the eccentric vessel. The concentric vessel is, however, required to be larger than the eccentric, in order that when turned down it may hold a given charge on each side without running out at the mouth or into the twyers. The ratio of the capacity of the concentric vessel to the eccentric vessel is as 3·5 to 5, but in consequence of the greater size, less slopping occurs, and much of the metal ejected during the boil falls back into the vessel. Now, the path over which the metal runs to the converter is very highly heated, and the slag afterwards formed more easily corrodes this more highly heated portion; hence the advantage of equalising this wear by pouring alternately into each side of the vessel. The concentric converter is generally made in four parts, connected by bolts and cotters for easy detachment.



13. STEEL ECCENTRIC CONVERTER

A 10-ton converter weighs about 40 tons; the steel or wrought iron plates are 1 in. thick, with 1 in. rivets and strong straps; the four parts are connected by pins and cotters. The belt and trunnions are in two pieces, formed of cast-iron box sections; the trunnions are 21 in. long. The belt weighs 11 tons, and is 10 ft. 8 in. in internal diameter. The tipping gear may consist of a worm-wheel 8 ft. in diameter, gearing into a screw of 4½ in. pitch, which receives its motion directly from the cranks of a pair of hydraulic engines mounted on one of the converter's standards. This allows of the vessel being turned over in either direction. A rack and pinion arrangement for tipping is much more common. A large converter of this kind for 15 ton charges is 24½ ft. high, and mounted on piers 20 ft. above the ground Such a vessel may weigh from 60 tons to 70 tons A wide nose may be advantageous from the point of view of reducing loss from ejected metal; but the narrower the nose the higher the possible working temperature, and the greater the amount of metal the vessel can hold in the horizontal position.

Cupola Furnace. The molten metal for supplying the converter may be melted in a cupola, or taken direct from the blast furnace, or from the latter to a receiver or mixer before finally passing to the converter.

The modern cupola is really a small blast furnace. In some cases the outside shell will be 10 ft. to 12 ft. in diameter, and the blast pressure as much as 2 lb. to 3 lb. per square inch. It is lined with a firebrick as a backing, and then rammed, usually with ganister or some other siliceous material. The height of the cupola platform should be such that when the cupola is *dumped*, or raked out, all the débris falls upon the floor level, and ample room should be left to enable the men to remove this easily. Cupolas with drop bottoms are now generally made, and found very convenient. A moderate sized cupola has an exterior diameter of about 6 ft. to 7 ft., with five or six twyers, and is worked with a blast pressure of 1 to 1½ lb. It will melt 200 to 300 tons of pig iron per 12 hours.

The position of the cupola is generally such that the metal can flow by gravity from the taphole to the Bessemer vessel, hence it is placed at a higher level. If the cupolas are too near the converter, the workmen are exposed to excessive heat, being between two great fires. On the other hand, if the cupolas are too far away, the long runners tend to chill the metal too much. and some of it will solidify, causing much waste In some works this difficulty has been overcome by using travelling iron ladles to convey the iron from the cupola to the converter, either by running on a track or by means of a crane

which admits of the tipping of the molten contents of a ladle into the converter.

Tipping ladles are now frequently used to convey cast iron from the cupola, or mixer, to the Bessemer converters. The ladle is held in a cast-iron trunnion belt by means of bolts and snugs. The tipping action is effected by a worm and screw motion actuating a trunnion, so that the workman can easily pour a charge of 20 tons of iron. The ladle is lined with firebricks with taper sides and fitting into one another. When these are built in, the whole is covered with a fireclay daubing. Another arrangement for tipping is by means of a chain fixed to the bottom and attached to a hydraulic cylinder, while the ladle is supported in the bearing of the carriage. The trunnions are not fixed centrally on the ladle, but somewhat in front, so that the whole metal can be poured into the converter by tilting without moving the ladle forward.

Ingot Moulds. The material from the ladle is teemed into cast-iron ingot moulds of various forms and sizes—square, circular, oval, octagonal, etc., open at both ends. They are made to taper considerably, being larger at the bottom than at the top, so as to allow for easy stripping. The usual method is to fill each mould separately, but the method of casting in groups is also used. A large ingot may be 19½ in. square, and weigh 50 cwt. For rails, the ingot is 14½ in. square, and weighs 25 to 30 cwt. Several smaller sizes are also used. The moulds are generally arranged in a shallow pit in a semicircle, so that the ladle crane may bring the nozzle of the ladle over each one in succession.

Sometimes, when an ingot is tapped, it is stoppered down by throwing some sand on it, and then covered with an iron plate, which is fastened down by a cross-bar and wedges. In group moulds they are generally arranged round a central one, somewhat taller than the rest, into which the metal is run, and whence it passes from the bottom to the bottoms of the others by means of fireclay tubes or passages. Hence the material rises in the moulds from the bottom to the top. A plan now largely adopted, especially in American works, is to have the ladle stationary, and a bogie truck carrying two moulds is run under the nozzle of the ladle for teeming. The bogie then conveys them away, and another pair is brought under the taphole, and so on in succession.

Basic Bessemer Process. This process is conducted in an ordinary converter, but a phosphoric pig iron may be used. Such an iron may contain 3 per cent. of carbon, 0·5 to 1 per cent. of silicon, 0·2 per cent. of sulphur, 1 to 2 per cent. of manganese, and 2 to 3 per cent. of phosphorus. In consequence of the basic lining, the slag is basic, and is capable of taking up phosphorus oxide. All acid substances tend to neutralise the base, so that only a certain quantity of acid material can be taken up. If, therefore, much silica be present, it will unite with the base in preference to the phosphorus oxide, which will be reduced and pass into the iron. To prevent this, excess of lime is necessary; but this raises the fusion point of the slag, and increases its quantity, so that a larger vessel is necessary. This means an addition to the cost, and an increase in the working expenses.

Now, grey pig iron generally contains much silicon, which renders it unsuitable for the basic process. White iron contains only a moderate amount of silicon, and is often high in phosphorus, which, being a good heat producer, and playing a similar part to that of silicon in the acid process, is required in the basic process. Another point of importance is the amount of phosphoric acid in the slag, whose value as a manure depends on its phosphorus content. Moreover, the purity of the lime is important, as impure lime may contain silica, and 1 lb. of silica requires 4 lb. of lime to neutralise it. Silica in lime generally amounts to about 2 per cent., and often more. In consequence of the lower temperature produced by the presence of lime, and the affinity of silica for such a strong base, the silicon is more thoroughly removed than in the acid process. Manganese is not, however, so completely removed. A highly basic slag is also favourable for the removal of sulphur, which takes place almost entirely during the after-blow.

Behaviour of Phosphorus. Phosphorus is not appreciably removed until most of the other elements have been eliminated and the heat of its oxidation is concentrated towards the end of the blow, when it is most required. Phosphorus is oxidised at the beginning of the blow; but, in the absence of a basic fluid slag rich in lime, the oxide is decomposed by the carburised iron at the high temperature prevailing in the converter. Towards the close the slag is highly basic, and then the oxidised phosphorus passes into the slag. On the addition of spiegeleisen or ferro-manganese at the end of the blow, some of the phosphorus is reduced from the slag and passes into the steel, probably due to the reducing action of the manganese.

At the end of the blow the iron is left in an oxygenated state to a greater extent than in the acid process, so that larger quantities of manganese compounds are required. To reduce the amount of oxide before adding the manganese compound, grey hæmatite pig iron is generally added, but the best method of preventing over-oxidation is to use good manganiferous pig iron.

The Basic Blow. The different stages of the basic blow are similiar to those described in the acid process, but during the boil larger quantities of slag are ejected. When the flame stops, instead of turning the vessel down and stopping the blast, as in the acid process, blowing is continued for three or four minutes longer. This is termed the *after-blow*, and during this period practically all the phosphorus is removed. The plant used in the basic process differs but little from that in the acid process, except that the concentric form of converter is more often used. The essential difference is in the lining, which must be strongly basic and sufficiently refractory to withstand the very high temperature to which it is subjected without melting or softening. The materials generally applied for the purpose are lime and burnt dolomite, mixed

with some cementing material, such as anhydrous tar.

Dolomite, or magnesium limestone, of high quality, and containing not more than 2 per cent. of silica, is desirable. It is first broken up into small lumps, and strongly calcined in a basic-lined cupola to remove moisture and carbon dioxide. The effect of this calcination is to produce a considerable shrinkage, and it is advisable to employ the shrunk material for lining the converter as soon as possible, otherwise it will absorb moisture from the air and rapidly deteriorate. It is next ground in a pug-mill and mixed with the desired amount of well-boiled tar. The prepared material is made into bricks of different sizes and shapes to suit the sweep of the converter. They are placed into position as soon as they come from the press.

Use of Small Converters. Although the general tendency has been to increase the capacity of the converters and the general adoption of bottom blowing, the small converter with side blowing is still used. These converters may be classified into *fixed*, *rotating*, *side blowing*, and *bottom blowing*.

Fixed Vessels. These converters have four chief defects. (1) They scarcely permit of bottom blowing, and therefore involve a great loss of iron in blowing. In bottom blowing the failure of a single twyer would let the whole charge escape. If a twyer in a rotating vessel fail, the vessel can easily be turned so as to bring the twyer above the level of the metal, when the faulty one can be repaired. This is a common occurrence. (2) Even in side blowing the failure of a twyer is a serious thing in a fixed vessel, because it is necessary to remove the charge at once, converting it into scrap. (3) At the end of the blow the charge has to be tapped out instead of being poured. Moreover, the proportion of carbon is less under control in the fixed vessel because of the length of time required to tap. (4) It is impossible to recarburise in the vessel, and this has to be done in the ladle. This is not important in mild steel, but in rail steel it is a serious thing. The fixed vessel is much cheaper than the rotating one, and in small works where the charges are small the low cost more than counterbalances the losses enumerated above.

Side Blowing. This may be near the bottom, as in the old Swedish converters, or higher up, as in the modern vessels. Side blast requires less blast pressure and therefore less cost in blowing engines, boilers, etc. The system has three chief disadvantages.

1. The action of the blast is not uniform through the metal, and the metal contains less carbon above than below the twyers, and although the portions may mix in the ladle, the metal is liable to be non-homogeneous.

2. The metal round where the blast enters is highly oxidised, while in bottom blowing the bath is so highly agitated that any oxidised portions are rapidly deoxidised by the carbon and silicon of the other part. Again, at the end of the blow the iron oxide escapes as a dense reddish-brown smoke along with the blast, and the metal is overblown. This imperfect mixing of iron oxide and the carbonated and silicated portions, in the case of side blowing, causes overblowing and consequent loss of iron.

In the old Swedish vessel the twyers were placed not radially, but in a tangential direction, so as to give to the metal a rotatory motion. The same is done in the Robert converter, which has also a vertical rotation by the twyer being on one side only.

3. The bottom and the sides near the twyers wear away more rapidly, causing the depth of metal to diminish, so that the blowing becomes more localised. In bottom blowing the depth of metal above the twyers changes but slightly, the corrosion being chiefly on the bottom. Side blowing has two advantages. It lessens the blast pressure, and prolongs the life of the twyers.

Clapp and Griffiths Converter. In this vessel the twyers were raised to about 10 in. above the bottom, so that when half the metal was tapped out the twyers were not out of the metal. The vessel is about 10 ft. high, 5½ ft. internal diameter, lined with silica bricks, and provided with four to six horizontal twyers, filled with valves for regulating the blast. As the slag rises it is run off through a slag-hole during the intermediate stages of the blow. At the conclusion the metal is tapped out the same as from a cupola. Ferro-manganese is added to the metal in the ladle. This process appears to eliminate the silicon, but leaves the phosphorus and sulphur practically untouched.

Hatton improved this form of converter by replacing the solid bottom with a movable one, and by introducing a simpler form of valve to regulate the blast. The movable bottom greatly facilitates repairs. The pig iron used must be practically free from phosphorus and sulphur, and contain 2 per cent. to 2·75 per cent. of silicon, otherwise the blow is too cold.

The Robert Converter. This, although a movable converter, is adapted only for small charges of from 1 to 3 tons. The blast is introduced near the upper surface of the metal, and the twyers inclined at different angles, so as to give a rotatory motion to the metal. The vessel itself is tilted during the first half of the blow, and turned more vertically as the operation proceeds, in order that the blast may be less strongly localised. The converter is mounted on trunnions and revolved in the usual way, but by means of hand gearing. The advantages claimed for this converter are several: No expensive blowing plant is required, the slag and gases separate better from the metal, a higher temperature is obtained, enabling castings to be made, the process can be stopped at any given moment, and steel can be made in varieties from the mildest to the hardest. The loss of metal in the Robert converter seems to be as great as in the fixed vessels, averaging about 20 per cent. The position of the twyers high up in the bath is a disadvantage, in that it leads to increased loss of metal by oxidation. The reduced pressure of the blast is an advantage.

A. H. HIORNS

The Two Systems of Bookkeeping. Method Adopted where a Journal is Subdivided. The Cash Book. Monthly Bank Totals.

THE MODERN CASH BOOK

The epitome of ledger accounts already given has preceded the observations and remarks which it was at first intended should accompany it. By this arrangement, an educational objection has been removed. It is unwise to encourage the facile reception of teaching of the kind that carefully forestalls every difficulty, because to do so is to discourage the much harder but far more precious habit of independent thought and speculation.

The Two Systems of Bookkeeping. It is desirable again to go through the now familiar list of transactions lettered *a* to *u*, this time with the object of noting and explaining, as they arise, the chief points of difference between the two systems of bookkeeping—namely, that under which all transactions were entered in the journal, and the other providing for their record in special books of original entry. Incidentally, there will be a clearing up of one or two little mysteries concerning those transactions for which, in the modern system, the double entry has hitherto appeared to be lacking.

Transaction (*a*). Cheque £5, drawn for petty cash. Here, on the very threshold of our subject, we discover a remarkable divergence between the old system and the new. Where the former has been preserved in its integrity, all cash items are journalised prior to being posted one by one, first to the cash account, and then to the personal accounts in the ledger.

Considerations of space forbid any sort of chronological treatment of our subject, and, therefore, we shall not enter upon an inquiry as to the time when the custom of writing up the cash account from the journal into a special book, instead of, as formerly, into the ledger, became prevalent. But this much is certain.

The True Conception of a Journal. As long as the cash account derived its component items from the journal in the same way as any other ledger account, so long was it entitled to be regarded as a part of the ledger, even though it was contained in another book. But as soon as the cash book assumed functions hitherto exercised by the journal, in other words, as soon as it became a book of original entry, it ceased to be a part of the ledger, and was in reality a journal. Now, the true conception of a journal is that of a book in which each day's transactions are entered in due form for posting to the ledger, and the words "in due form" signify that the entries must be so arranged as to ensure that the money totals of the debits and credits journalised and posted shall equal one another. We observe that this is the case in the example before us where the debits and credits in the ledger epitome severally aggregate £469 15s. 2d.

Classified Transactions. But where the journal is sub-divided, separate books being devoted to special classes of transactions, it is unnecessary to set out every entry in debit and credit form. It is sufficient if one term of each equation is recorded, care being taken to see that the terms are either all debit or else all credit. The equalisation of the debits and the credits is performed at stated—usually monthly—intervals, and resolves itself into a question of correctly casting the debits (or credits) previously entered and posted to their several accounts. The double entry is completed by posting the total ascertained as above to some account in the ledger on the opposite side to that to which the details have been carried.

We could not have a better illustration of this principle than is afforded by the day book shown on page 539. The total sales for September, 1905, are there stated as £792 6s. 2d. As a matter of fact the amount includes sundry charges for foreign parcel-post, but for present purposes this element may be neglected. The figures between transverse lines in the margin of the day book refer not to the accounts in our ledger epitome, but to the folios in Messrs. Bevan & Kirk's Sold ledger, where the respective accounts of Springer, Bruce, and Aird Bros. are to be found. In like manner the three ledger accounts will each contain a reference to D.B. 355—the folio number.

It needs but a glance at the day book to see that the entries are not set out as in the old style journal—that is to say, in debit and credit form; but at the same time it is quite clear that if all the September day book debits posted separately to Bevan & Kirk's sold ledger amount to £792 6s. 2d., the requirements of double entry are sufficiently complied with by posting that amount *in total* to the credit of the sales or goods account in the ledger.

The Debit Side of the Cash Book. Having demonstrated the principle that the total debit for a given period in a book of original entry demands an equal credit, and vice versa, let us apply that principle to the cash book. We find on page 536 a specimen folio of Messrs. Bevan & Kirk's bank cash book. First let us examine the debit side.

Bearing in mind what has already been said on the subject, we shall experience little difficulty in arriving at the following conclusions: (*a*) As all receipts of cash are lodged regularly at the bank without deduction, whatever moneys are credited to customers' and other accounts should simultaneously be debited to the bankers. (*b*) This process, if carried out, would constitute perfect double entry, and there would be no

object in keeping a separate cash account as distinguished from a petty cash account. (*c*) The entries in the bank column are in the form advocated for specialised books of original entry—that is to say, every item furnishes one term of an equation:

Bank Dr. to Customer.

(*d*) The several items being posted in detail to the *credit* of the various personal accounts, the debit is derived from the total of the bank column, £514 16s. 11d., less the balance as at September 1st, say £50. The double entry is, therefore, completed by posting £464 16s. 11d., which represents the actual amount of cash received during September, to the debit of bank account in the ledger.

The items in the discount column (Dr. side) are similarly treated, except that there is no starting balance to take into account; thus the details composing the total of £9 3s. 0d. are posted separately to the various personal accounts, while the total itself is carried to the debit of the discount account.

The Credit Side of the Cash Book. Coming now to the credit side of the cash book, the discount items will be posted to the debit of the personal accounts affected, while the total of £13 9s. 9d. must go to the credit of discount account.

The amounts appearing in the bank column (Cr. side) represent cheques drawn by Messrs. Bevan & Kirk on their bank, and paid away to different persons who are debited, the bankers being simultaneously credited. But whereas the debits must be posted separately, it will suffice to post one credit to the bank account for cheques drawn during the month, the amount of the credit being derived from the total of the bank column, £514 16s. 11d., less £34 5s. 1d. balance carried forward—that is, the cheques drawn in September, plus the bank charge for discounting Wake's acceptance, totalled £480 11s. 10d.

Bank Accounts in the Ledger. Below is an illustration of the bank account in the ledger. The initial balance of £50 has been brought forward from August 31st in the same way as the balance as at September 30th has been carried forward to October 1st. The debit of £464 16s. 11d., and the credits of 3s. and £480 8s. 10d., are authorised by journal entries as given below.

Dr.	Bank a/c						Contra				Cr.
1905						1905					
Sept 1	To Balance	b/f	50	·		Sept 30	By Bank charges			3	·
30	· Lodgments		464	16	11		· Cheques drawn		480	8	10
							· Balance	c/d	34	5	1
			£514	16	11				£514	16	11
Oct 1	To Balance	b/d	34	5	1						

27 Journal.

19									
Sept.	30	Bank Dr. to Sundry Debtors. Cash received and paid into Bank during month	GL 4 CB 45	464	16	11	464	16	11
		Trade Expenses Dr. to Bank. Charge for discounting Wake's acceptance ..	CB 45 GL 4		3	0		3	0
		Sundry Creditors Dr. to Bank. Cheques drawn during month	CB 45 GL 4	480	8	10	480	8	10

Some bookkeepers consider the bank account in the ledger superfluous, because it is simply an epitome of the figures contained in the bank columns of the cash book. In other words, the bank account is already in the cash book in detail, and does not need a place in the ledger. Where the bank balance is carried forward month by month in the cash book, as in the example before us, it is true that the bank account might be omitted from the ledger without much harm being done. But there is something to be said in favour of having every account in the ledger, and the extra time expended in securing this result will not be wasted.

Sometimes the balances are not shown in the cash book, and then it is imperative to have a bank account in the ledger. In such case the bank columns in the cask book are totalled monthly and ruled off without being equated, and the totals are posted to the ledger direct. Had this plan been adopted in our example on page 536 the debit total would have amounted to £464 16s. 11d.—actual receipts during September, and the credit total to £480 11s. 10d.—actual payments for the same period. After

the direct posting of these items the bank account in the ledger would show the same balance as it did when the lodgments and drawings were first journalised and then posted.

We may now post the lodgments total direct to debit and the drawings total direct to credit of bank account in the ledger, marking in the cash book folio columns the ledger folio occupied by the bank account, marking also in the folio columns of bank account the cash book folio from which the posted items have been copied.

Cross References. Particular attention is directed to the cross references here mentioned—namely, the reference in cash book to the ledger folio and the references in bank account to the cash book folio. Every ledger posting should reveal its place of origin, and every entry in a cash book or other journal should reveal its station in the ledger.

We now return to our dissected figures for the bank columns in the cash book. The lodgments total having been posted to debit of bank account, the drawings total will go to credit of same account, as will also the bank charge of 3s. But with regard to the initial balance of £50, and the ending balance of £34 5s. 1d., these amounts cannot be posted to the ledger, as they are contras to equivalent amounts appearing elsewhere in the cash book. Thus the debit of £50, with which September starts, is offset by the credit of £50, with which August ends. The two amounts explain and justify each other. The very condition of their existence is that they shall take opposite sides to one another, so that the credit of £50 cannot be created unless a debit of equal amount be created at the same time, thereby vindicating the primary law of a debit for every credit.

By the same rule the ending balance of £34 5s. 1d., which at September 30th is carried forward on the credit side, is brought forward on the debit side as at October 1st as the beginning balance for October. It is evident that to post either the £50 or the £34 5s. 1d. to the ledger would be to transgress the law, because the double entry for both these items has been already completed in the cash book itself. This point is worthy of notice, because the theory involved underlies every "balance" entry made in books of account—that is, every entry the amount of which is preceded by the words "To balance" or "By balance." Consider the account of J. Wake as set out below.

The credit entry "By balance c/d £7 7s 4d." tells us that the debits exceeded the credits by a certain sum—namely, £7 7s. 4d. If we accept this figure as the starting point of a new account, we virtually promise to close the old account by making a balance entry on the credit side, the amount of which shall equal the new debit. The entry is, in fact, our warrant for the contra entry, and the two entries together constitute a double entry, thus conforming to the established principle of a debit for every credit.

Treatment of Monthly Bank Totals. The journal entries exhibited earlier remain to be dealt with. These are intended to show how the monthly bank totals should be treated where the system prevails of passing all monthly totals from the books of original entry through the Journal on their way to the ledger. With regard to the posting of these entries the effect on the bank account has been explained. "GL 4" means that the bank account is on folio 4 of the General ledger. There should be a reference also in the folio columns of the bank account to Journal 27.

179 Dr. J. Wake. Contra Cr. 179

1905									1905								
Aug 20	To Goods DB	305	4	7	8				Sep 16	By Bill CB	45	20	10	6			
Sep 1	" do	320	9	8	7				20	" Balance	c/d	7	7	4			
17	" do	327	6	14	3												
20	" do	341	7	7	4												
						£27	17	10							£27	17	10
Sep 20	To Balance	b/d				7	7	4									

In the Journal folio column level with the credit of £464 16s. 11d. there will be found, in place of the usual reference to a ledger folio, a reference to CB 45. On referring back to CB 45 we discover the reason for this—namely, that the various items of which the journal credit is composed have been posted to the credit of their respective accounts *from the cash book*. In like manner, the journal debit of 3s., and the several items aggregating the journal debit of £480 8s. 10d., have been posted to the debit of their respective accounts from the cash book. There is therefore no need to post them again from the journal.

How to Test the Balance. Before deserting the bank account, let us see how the accuracy of the balance may be tested by comparison with that shown in the bank pass book. The pass book discloses the state of Messrs. Bevan & Kirk's banking account as it appears from the records of the bank, and not necessarily as shown by the firm's cash book. Naturally enough, the pass-book balance and the cash-book balance seldom coincide. On

the one hand, cheques received by the firm are entered in the cash book under date of *receipt*, but they are acknowledged in the pass-book under date of *clearing*, which, in the case of long distance cheques—say a cheque drawn on Dublin and remitted to London—would be several days later than the date of receipt by Bevan & Kirk. On the other hand, cheques drawn by Bevan & Kirk are entered in the cash book under date of issue, but in the pass book they appear, of course, under date of *payment by the bank*.

Delay in presenting cheques for payment frequently occurs, and must be taken into account in trying to agree the pass book with the cash-book. A simple illustration of a pass book agreement will now be given. Mr. Kirk obtained the firm's pass book from the bank on October 5th and found there was a balance of £42 6s. 11d. at credit of the firm on October 1st. Having succeeded in reconciling this balance with that shown in his cash book, he made a red ink memorandum on the cash book thus:

1905.		£	s.	d.
Oct. 1.	Balance as per P.B.	42	6	11
	Add cheque not cleared (Jones) ..	29	8	2
		71	15	1
	Less cheque not presented	37	10	0
	Balance as per C.B.	£34	5	1

It is probable that as Mr. Kirk has postponed the checking of the pass book until October 5th, he will be able to satisfy himself from it that since October 1st the commission cheque from Jones has been duly cleared and the rent cheque duly presented and paid, but that does not affect the position as at October 1st, with which he is at the moment concerned.

A. J. WINDUS

SHORTHAND—LESSON 7. BY SIR ISAAC PITMAN & SONS

The Halving Principle. Light consonants are made half their usual length to indicate the addition of *t*; thus

ache, ached, sect, Kay, Kate, skate.

Heavy consonants are made half their usual length to indicate the addition of *d*; thus

ebb, ebbed, bow, bowed, gay, guide.

When a consonant is hooked *finally*, it may be halved to express the addition of EITHER *t* OR *d*; thus *paint* or *pained*; *plant* or *planned*; *tint* or *tinned*; *tents* or *tends*.

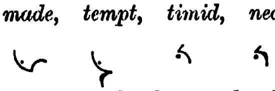
In words of *more than one syllable*, with certain exceptions, a letter may be halved to express the addition of EITHER *t* OR *d*; thus

between, Bedwin, rabbit, rabid, credit.

forward (*wd* contraction for *-ward*); *dockyard* (*yd* contraction for *-yard*).

The four light consonants are also halved and thickened to represent the addition of *d*; thus

mate, made, tempt, timid, neat, need,

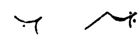


felt, felled, heart, hard.

When a vowel comes between *l-d*, or *r-d*, these consonants must be written in full; thus

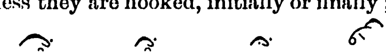
pallid, parade, mellowed, married.

Lt is written upward except after *n*, *ng*, when it is written downward, as



knelt, ringlet.

The consonants *mp*, *ng*, cannot be halved to express the addition of either *t* or *d*, unless they are hooked, initially or finally; thus



impugn, impugned, impend, slumbered,

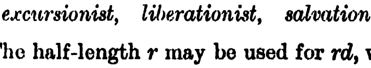
rampart, anger, angered or *anchored.*

The double consonants *lr*, *rr*, cannot be halved for the addition of *t* or *d* under any circumstances.

EXERCISE

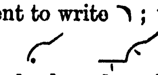
1. Pet, pit, Tate, taught, kit, aft, cast, shot.
2. Bed, aided, edged, jade, goad, egged, mead.
3. Old, erred, blade, bread, glade, broad, dread.
4. Pound, fined, accident, inward, brickyard.
5. Meat, mud, night, Ned, admit, doomed.
6. Bailed, ballad; showered, charade; tarred.
7. Pelt, polite, kilt, melt, omelet, inlet, runlet.
8. Impound, dampened, lingered, hungered.

After the *-shun* hook, the stroke *st* may be written upward; thus



excursionist, liberationist, salvationist.

The half-length *r* may be used for *rd*, when it is not convenient to write ; thus

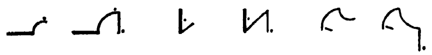


lard, coloured.

Half-sized *t* or *d* immediately following the consonants *t* or *d* is always disjoined; thus

tided, dated, treated, dreaded, hesitated.

When a word ends with *t* or *d* followed by a vowel, the letter must be written in full, and not indicated by the halving principle; thus



guilt, guilty; dirt, dirty; loft, lofty.

The circle *s* is always read *last* at the end of an outline; thus

pun, punt, punts; join, joint, joints.

EXERCISE

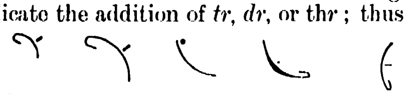
1. Hate, height, hit, hits, huffed, hounds.
2. Fashionist, elocutionist; evolutionist.
3. Fitted, potted, jotted, netted, rooted, pirated.
4. Branded, grounded, stunted, unacquainted.
5. Fort, forty; malt, malty; neat, natty.
6. Tin, tint, tints; pine, pint, pints.

Grammalogues. The following additional grammalogues should be memorized:

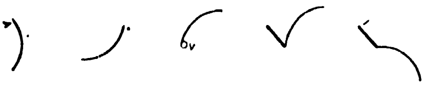
called(¹), *cannot*(¹), *could, great, not*(¹),

short(¹), *told, towards, that*(¹), *without.*

The Double-Length Principle. Curved consonants are made twice their usual length to indicate the addition of *tr*, *dr*, or *thr*; thus



flow, floater, father, vendor, thunder,



oyster, shatter, slighter, builder, border.

When *dr* or *thr* follow an initial *l*, they are expressed by and not by doubling the *l*; thus

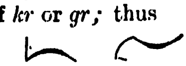
older, leader, leather.

Straight consonants hooked finally, or initially circled or following another stroke, are made twice their usual length to indicate the addition of *tr* or *dr*; thus

pain, painter, scatter, nectar, rector,

detractor, disputer, debater.

The character *mp* is doubled to express the addition of *r*, and is doubled to express the addition of *kr* or *gr*; thus



temper, longer.

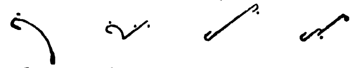
The signs are doubled in length for the addition of *er*; as

lingerer, lumberer.

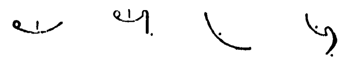
In a few common words, it is allowable to double a letter to express the addition of the syllable *-ture*; thus

feature, future, signature, picture.

When a word ends with a vowel preceded by *tr, dr*, or *thr*, these consonants must be *written* and not indicated by doubling; thus



flatter, flattery, winter, wintry,



sunder, sundry, feather, feathery.

The circle *s* at the end of a double-length character is read *last*, as usual; thus

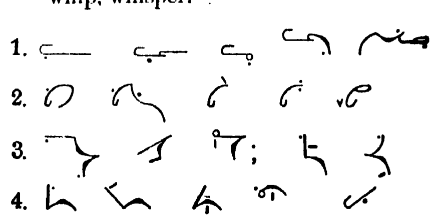
tenders, feathers, counters.

EXERCISE

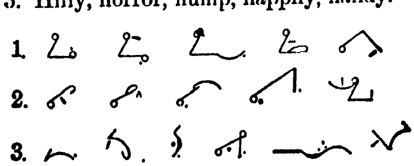
1. Enter, Easter, loiter, shutter, matter.
2. Founder, asunder, smatter, cylinder, Walter.
3. Letter, louder; latter, ladder; fetter, feeder.
4. Pointer, tinder, ranter, wander, wandered.
5. Vamper, Humber, jumper, timber, belonger.
6. Slumber, slumberer, lumberer.

KEY TO EXERCISES IN LAST LESSON

1. Quibble, quiet, quarter, quarrel, require, guano, languish.
2. Weal, wallow, wealth, Wells, wheel, whelm, meanwhile, wheeler.
3. Fuller, roller, scholar, poorer, admirer, borer, snorer.
4. Pump, jump, embellish, ambitions, whack, whip, whisper.



1. Hock, haggis, hod, hoary, haddock.
2. Hive, haggle, hairy, cohesion, unhinge.
3. Hilly, horror, hump, happily, handy.



Reduction to Lowest Terms. Comparison of Fractions. Addition, Subtraction, and Multiplication.

FRACTIONS

69. An *integer*, or *whole* number, is a number which consists of a collection of *complete* units.

Thus 6 is a whole number; 6 pence means six *complete* pence.

A *fraction* is a quantity less than the unit.

We have already examined (Art. 29) how quantities less than the unit can be expressed in the decimal notation. When so expressed, they are called *decimal fractions.*

70. We shall now consider a second notation by which fractions may be represented.

We have already used $\frac{3}{4}$d. to express three farthings. This meant that, the unit having being divided into four equal parts, *three* of these *fourth parts* made $\frac{3}{4}$ of the unit. In the same way, when a unit is divided into five equal parts, each of these parts is called a *fifth*, and is represented by $\frac{1}{5}$; two of the parts make two-fifths, or $\frac{2}{5}$.

If the unit is divided into six, seven, eight, or more parts, the parts are called sixths, sevenths, eighths, and so on; and are represented by $\frac{1}{6}$, $\frac{1}{7}$, $\frac{1}{8}$, and so on.

Thus, a fraction can be represented by means of two numbers, one of them being the number of equal parts into which the unit is divided, and the other the number of these equal parts indicated by the fraction. The two numbers are written one above the other, and are separated by a line.

The number below the line, because it gives a *name* to the parts, is called the *Denominator.*

The number above the line, which tells the *number* of these equal parts denoted by the fraction, is called the *Numerator.*

Fractions expressed in the above manner, such as $\frac{5}{9}$, $\frac{11}{13}$, are called *Vulgar* Fractions, that is, *Common* Fractions.

A whole number can be expressed, in this notation, as a fraction with any required denominator. For, when the numerator is equal to the denominator, the fraction denotes that as many equal parts are to be taken as that into which the unit was divided: so that $\frac{4}{4}$, $\frac{5}{5}$, or $\frac{10}{10}$ each represents a unit. Therefore, when the numerator is a *multiple* of the denominator, the fraction denotes as many equal parts of the unit as make up that multiple of the unit. Thus, $\frac{8}{4}$, in which the numerator is twice the denominator, represents twice the unit; that is, $\frac{8}{4} = 2$.

71. We have defined a fraction as a quantity *less* than the unit. Evidently, then, a fraction should have its numerator less than its denominator. But suppose we have divided several units, each into the same number of equal parts, say 15, and that we take more than 14 of such parts, say 17, we then obtain a quantity which is equal to seventeen-fifteenths of the unit, or $\frac{17}{15}$. Such a quantity is evidently not less than the unit, and is not, strictly speaking, a fraction. The two cases are distinguished thus:

A *Proper Fraction* is a fraction whose numerator is less than its denominator.

An *Improper Fraction* is a fraction whose numerator is not less than its denominator.

72. A *mixed number* is the sum of a whole number and a fraction.

Thus, the sum of 4 and $\frac{5}{8}$ is a mixed number. It is written $4\frac{5}{8}$.

A mixed number can always be expressed as an improper fraction.

Example. Reduce $5\frac{4}{9}$ to an improper fraction.

Each unit of the 5 contains 9 ninths.

$\therefore$ 5 units contain $5 \times 9 = 45$ ninths.

Thus $5\frac{4}{9} = \dfrac{5 \times 9 + 4}{9} = \dfrac{49}{9}$ *Ans.*

Again, an improper fraction is converted into a mixed number by dividing the numerator by the denominator. The quotient will be the whole number, and the remainder will be the numerator of the proper fraction.

Example. Express $\frac{43}{5}$ as a mixed number.

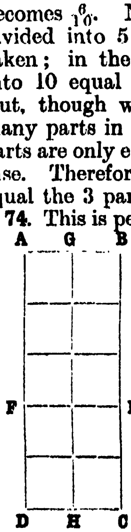
When 43 is divided by 5, as the quotient is 8, and the remainder 3.

$\therefore \dfrac{43}{5} = 8\frac{3}{5}$ *Ans.*

73. *If the numerator and denominator of a fraction are both multiplied by the same number the value of the fraction is not altered.*

Consider the fraction $\frac{3}{5}$. If we multiply both numerator and denominator by 2, the fraction becomes $\frac{6}{10}$. Now, in the fraction $\frac{3}{5}$, the unit is divided into 5 equal parts and 3 of these are taken; in the fraction $\frac{6}{10}$ the unit is divided into 10 equal parts and 6 of them are taken. But, though we divide the unit into twice as many parts in the second case, yet two of these parts are only equal to one of the parts in the first case. Therefore, the 6 parts in the second case equal the 3 parts in the first—*i.e.*, $\frac{3}{5} = \frac{6}{10}$.

74. This is perhaps made plainer by a diagram.



Let A B C D represent the unit. Divide this into 5 equal parts by drawing lines parallel to A B. Then A B E F, consisting of 3 of these strips, will represent $\frac{3}{5}$ of the unit.

Now divide A B C D into 10 equal parts by drawing a line parallel to A D. Then A B E F contains 6 of these parts, and therefore represents $\frac{6}{10}$ of

the unit. Hence, since A B E F represents both $\frac{3}{5}$ and $\frac{6}{10}$, it follows that $\frac{3}{5} = \frac{6}{10}$.

75. We have shown that $\frac{6}{10}$ and $\frac{3}{5}$ are equal. Now, $\frac{3}{5}$ is obtained from $\frac{6}{10}$ by *dividing* both numerator and denominator by 2. Hence, the statement in Art. **73** is also true if we substitute "divided" for "multiplied." Therefore, the numerator and denominator of any fraction may always be divided by any common factor that they contain.

When we have divided out (or *cancelled*), all the common factors of the numerator and denominator, the fraction is said to be *in its lowest terms*.

76. Reduction to Lowest Terms. In finding the common factors of the numerator and denominator the rules given in Art. **56** should be applied. When, however, common factors cannot easily be seen, it is better to find at once their H.C.F. by the ordinary rule.

Example 1. Reduce $\frac{5115}{11880}$ to its lowest terms.

Here $\frac{5115}{11880} = \frac{1705}{3960}$ (dividing numerator and denominator by 3),

$= \frac{341}{792}$ (dividing by 5),

$= \frac{31}{72}$ (dividing by 11).

Now, 31 is a prime number, and it does not divide 72,

$\therefore \frac{31}{72}$ is in its lowest terms.

Example 2. Reduce $\frac{1582}{10057}$ to its lowest terms.

By trial, 2, 3, 5, 7, 11, 13 are none of them common factors, so we find the H.C.F.

2	1582	10057	6
4	452	565	1
	...	113	

The H.C.F. is 113. Divide numerator and denominator by 113. The quotients are 14 and 89,

$\therefore \frac{1582}{10057} = \frac{14}{89}$ *Ans.*

H.C.F. working can be more compactly arranged than by the method in Art. **60**. Here, the first remainder is 565. We now divide this into 1582, writing the quotient, 2, on the left. Remainder is 452. Divide this into 565, putting the quotient on the right; and so on.

77. Any fraction can be expressed with a denominator which is any given multiple of its original denominator.

Example 1. $\frac{3}{4}$ can be expressed with denominator 7 × 4.

Thus $\frac{3}{4} = \frac{7 \times 3}{7 \times 4} = \frac{21}{28}$; for the value of the fraction is not altered when we multiply both numerator and denominator by 7.

It is now clear that any number of fractions can be expressed as fractions with a denominator which is some *common* multiple of the original denominators. It is generally most convenient to use the *least* common multiple.

Example 2. Reduce $\frac{3}{7}$, $\frac{5}{14}$, $\frac{8}{21}$ to a common denominator.

The L.C.M. of 7, 14, 21 is 42. Therefore, we express each fraction as a fraction with denominator 42.

Thus $\frac{3}{7} = \frac{3 \times 6}{7 \times 6} = \frac{18}{42}$,

$\frac{5}{14} = \frac{5 \times 3}{14 \times 3} = \frac{15}{42}$,

$\frac{8}{21} = \frac{8 \times 2}{21 \times 2} = \frac{16}{42}$.

The multiplier for each fraction is, of course, found by dividing its denominator into the common denominator 42.

78. Comparison of Fractions. When we have reduced any given fractions to a common denominator, we see at once that the one with the largest numerator is the greatest fraction. For instance, in Ex. **2** of the last article, the three fractions were found equivalent to $\frac{18}{42}$, $\frac{15}{42}$, and $\frac{16}{42}$. But $\frac{18}{42}$ is greater than either $\frac{15}{42}$ or $\frac{16}{42}$—*i.e.*, $\frac{3}{7}$ is the greatest of the given fractions.

Example. Arrange in ascending order of magnitude,

$$\frac{13}{15}, \quad \frac{11}{14}, \quad \frac{31}{35}, \quad \frac{17}{21}.$$

Find L.C.M. of denominators:

3	15, 14, 35, 21
7	5, 14, 35, 7
	2, 5

L.C.M. = 3 × 7 × 2 × 5 = 210.

$\frac{13}{15} = \frac{13 \times 14}{15 \times 14} = \frac{182}{210}$; $\frac{11}{14} = \frac{11 \times 15}{14 \times 15} = \frac{165}{210}$;

$\frac{31}{35} = \frac{31 \times 6}{35 \times 6} = \frac{186}{210}$; $\frac{17}{21} = \frac{17 \times 10}{21 \times 10} = \frac{170}{210}$.

Therefore, the fractions in ascending order are

$$\frac{165}{210}, \quad \frac{170}{210}, \quad \frac{182}{210}, \quad \frac{186}{210};$$

or, $\frac{11}{14}, \quad \frac{17}{21}, \quad \frac{13}{15}, \quad \frac{31}{35}$ *Ans.*

79. We can also compare the magnitude of fractions by reducing them to a common *numerator*, in which case the fraction with the *least* denominator is the greatest fraction.

Example. Which is greater, $\frac{3}{7}$ or $\frac{2}{5}$.

Here, L.C.M. of the numerators is 6,

and $\frac{3}{7} = \frac{3 \times 2}{7 \times 2} = \frac{6}{14}$,

$\frac{2}{5} = \frac{2 \times 3}{5 \times 3} = \frac{6}{15}$;

$\therefore \frac{6}{14}$, *i.e.*, $\frac{3}{7}$, is the greater fraction.

80. Addition of Fractions. If two or more fractions have the same denominator, their sum is obtained by adding the numerators.

Thus, $\frac{1}{7} + \frac{4}{7} + \frac{5}{7} = \frac{1+4+5}{7} = \frac{10}{7} = 1\frac{3}{7}$.

If the fractions have different denominators, we must first express them as equivalent fractions with the same denominator. (Art. **77**).

Example 1. Find the value of

$$\frac{1}{9} + \frac{3}{7} + \frac{5}{21} + \frac{2}{3}.$$

The L.C.M. is 63. The several denominators, when divided into 63, give 7, 9, 3, 21 respectively, for quotients. Therefore, we multiply the numerators and denominators of the fractions by 7, 9, 3, 21, and add the numerators to obtain the required sum. The result must be reduced to a mixed number, or to lower terms, if necessary.

The work is arranged thus:

$$\frac{1}{9}+\frac{3}{7}+\frac{5}{21}+\frac{2}{3},$$
$$=\frac{7+27+15+42}{63},$$
$$=\tfrac{81}{63}=1\tfrac{18}{63}=\underline{1\tfrac{2}{7}\ \textit{Ans.}}$$

In adding mixed numbers, first add the whole numbers, then the fractions, finally adding the two results.

Example 2. Add together $3\frac{1}{8}+\frac{7}{24}+7\frac{11}{15}+4\frac{3}{20}$.

Given expression

$$=3+7+4+\tfrac{1}{8}+\tfrac{7}{24}+\tfrac{11}{15}+\tfrac{3}{20},$$
$$=14+\frac{15+35+88+18}{120},$$
$$=14+\tfrac{156}{120}=14+1\tfrac{36}{120}=\underline{15\tfrac{3}{10}\ \textit{Ans.}}$$

81. Subtraction of Fractions. The principle is the same as in addition. Reduce the fractions, if they have different denominators, to a common denominator, and then take the difference of the numerators. In the case of mixed numbers, subtract the whole numbers and the fractions separately.

Example 1. Take $4\frac{5}{21}$ from $6\frac{3}{7}$.

$$6\tfrac{3}{7}-4\tfrac{5}{21}=6-4+\tfrac{3}{7}-\tfrac{5}{21},$$
$$=2+\frac{9-5}{21},$$
$$=2+\tfrac{4}{21}=\underline{2\tfrac{4}{21}\ \textit{Ans.}}$$

If the fractional part of the number to be subtracted be greater than the fractional part of the other number, we proceed as follows:

Example 2. From $7\frac{4}{15}$ take $4\frac{11}{25}$.

$$7\tfrac{4}{15}-4\tfrac{11}{25}=7-4+\tfrac{4}{15}-\tfrac{11}{25},$$
$$=3+\frac{20-33}{75},$$
$$=2+\frac{75+20-33}{75},$$
$$=2+\tfrac{62}{75}=\underline{2\tfrac{62}{75}\ \textit{Ans.}}$$

Example 3. Simplify $3\frac{2}{9}+4\frac{5}{7}-5\frac{13}{21}+\frac{2}{35}-1\frac{14}{15}$.

Given expression

$$=3+4-5-1+\tfrac{2}{9}+\tfrac{5}{7}-\tfrac{13}{21}+\tfrac{2}{35}-\tfrac{14}{15},$$
$$=1+\frac{70+225-195+18-294}{315},$$
$$=1+\frac{313-489}{315},$$
$$=\frac{628-489}{315}=\frac{139}{315}\ \underline{\textit{Ans.}}$$

The third line in working out this simplification is obtained by adding all the numerators with + before them, and then all those with − before them.

82. Multiplic[illegible]on of Fractions. (i.) When the multi[illegible] a whole number. This, as in the case [illegible]le numbers (Art. 15), means that we hav[illegible]nd the *sum* of a given number of repetitions of the fraction.

Example 1.

$$\frac{7}{9}\times 4 \text{ means } \frac{7}{9}+\frac{7}{9}+\frac{7}{9}+\frac{7}{9},\ \textit{i.e.,}\ \frac{28}{9};$$

or

$$\frac{7\times 4}{9}.$$

Hence, *to multiply a fraction by a whole number, simply multiply the numerator by that number.*

Since the multiplier thus becomes a factor of the numerator, we *cancel* (Art. 75) any common factors contained in the multiplier and the denominator; and this may be done *before* we perform the actual multiplication. Thus:

Example 2. Multiply $\frac{19}{46}$ by 69.

$$\frac{19}{46}\times 69=\frac{19\times 69}{46}=\frac{19\times 3}{2}\ \text{(cancelling 23)},$$
$$=\tfrac{57}{2}=\underline{28\tfrac{1}{2}\ \textit{Ans.}}$$

It follows, that, if the multiplier be itself a factor of the denominator, we may, *to multiply a fraction by a whole number, divide the denominator by that number.*

(ii.) When the multiplier is a fraction.

In performing the operation 7 × 9, it is plain that we do to 7 what we do to a unit to obtain 9. Similarly, $\frac{3}{5}\times\frac{4}{11}$ may be looked upon as doing to $\frac{3}{5}$ what we do to the unit to obtain $\frac{4}{11}$.

Now, to obtain $\frac{4}{11}$ from the unit, we must divide the unit into 11 equal parts and take 4 of them.

Therefore, to find the value of $\frac{3}{5}\times\frac{4}{11}$ we must divide $\frac{3}{5}$ into 11 equal parts and take 4 of them.

But $\frac{3}{5}=\frac{33}{55}$ (Art. 73) $=\frac{3}{55}\times 11$ (Art. 82, i), so that, the eleventh part of $\frac{3}{5}$ is $\frac{3}{55}$; and, if we take 4 of these parts, we get $\frac{3}{55}\times 4$, or $\frac{12}{55}$.

Thus, $\frac{3}{5}\times\frac{4}{11}=\frac{12}{55}$. Now $12=3\times 4$, and $55=5\times 11$.

Hence we have the following rule: *To multiply two fractions together, multiply the numerators for a new numerator and the denominators for a new denominator.*

As in Ex. 2 the work is shortened if we cancel common factors from the numerators and denominators.

Example 3. Multiply $\frac{22}{91}$ by $\frac{13}{77}$.

$$\text{The product}=\frac{\overset{2}{\cancel{22}}\times\cancel{13}}{\underset{7}{\cancel{91}}\times\underset{7}{\cancel{77}}}=\underline{\frac{2}{49}\ \textit{Ans.}}$$

Here, the 22 of the numerator and the 77 of the denominator contain a common factor, 11. Therefore, we cross out the 22 and write 2 above it, and cross out the 77 and write 7 under it. Similarly, we cancel the factor 13 from 13 and 91. There is now 2 left for numerator and 7×7 for denominator.

To multiply more than two fractions together, we proceed in the same way.

In multiplication of fractions, mixed numbers must first be expressed as improper fractions.

Example 4. Simplify $5\frac{1}{7}\times\frac{11}{27}\times 1\frac{11}{24}$.

$$\text{Given expression}=\frac{\overset{\cancel{3}}{\cancel{36}}}{\cancel{7}}\times\frac{11}{\underset{9}{\cancel{27}}}\times\frac{\overset{5}{\cancel{35}}}{\underset{2}{\cancel{24}}},$$
$$=\tfrac{55}{18}=\underline{3\tfrac{1}{18}\ \textit{Ans.}}$$

H. J. ALLPORT

END OF VOLUME ONE

A KEY TO THE HARMSWORTH SELF-EDUCATOR

From this table of the 25 groups of the Self-Educator the student may find the place of any subject treated in the work. The main groups appear in regular numerical order in each part of the Educator, each group continuing until complete. The sub-divisions of the groups appear as nearly as possible in the order of this page.

Group 1. Success

The Secrets of a Successful Life. Personality. Applied Education. Ideas. The Qualities that Win in the World.

Group 2. Geography and Travel

GEOGRAPHY. Physical, Political, and Commercial.
TRAVEL. Educational Travel. How to See the World.

Group 3. Arts and Crafts

ART. Ideals and History of Art. The Old Masters.
DRAWING. Freehand. Object. Brush. Memory. Light & Shade.
PAINTING. Theory and Training.
DESIGN. Design in Crafts and Trades. Book-decoration. Illumination. Design for textiles, wallpapers, metal work.
SCULPTURE. Modelling. Chiselling. Casting.
ARCHITECTURE. Theory. Styles. Training.
CARVING. Wood. Bone. Ivory. Tortoiseshell.
ART METAL WORK. A Practical Course.
PHOTOGRAPHY. A Course of Simple Lessons with a Camera.

Group 4. Physiology and Health

PHYSIOLOGY. Structure and Working of the Human Body.
HEALTH. The Laws of Health and Personal Hygiene.

Group 5. Agriculture and Gardening

FARMING. A Practical Course in the Cultivation of the Earth. Live-stock. Dairying. Poultry. Beekeeping.
FORESTRY. The Theory and Practice of Managing Trees.
GARDENING. Gardens for Pleasure and Profit.

Group 6. Chemistry

CHEMISTRY. Complete Course in Theory and Practice.
APPLIED CHEMISTRY. The Applications of Chemistry in Industry. Chemical Analysis. Acids and Alkalies. Oils and Fats. Waxes. Candles. Soap. Glycerine. Volatile Oils and Perfumes. Paints and Polishes. Glues. Starch. Inks. Coal Tar Products. Wood Distillation. Celluloid. Matches. Artificial Manures. Electro-chemistry. Water-Softening. Waste Products. Artificial Silk.

Group 7. History

The Story of All Ages and Peoples for Over Ten Thousand Years—From Egypt and Babylon to Europe in 1914.

Group 8. Civil Engineering and Transit

CIVIL ENGINEERING. Surveying. Varieties of Construction. Reinforced Concrete. Roads. Bridges. Railways and Tramways. Water Supply. Sewerage. Refuse. Hydraulics. Pumps. Harbours. Docks. Lighthouses.
VEHICLES. Construction and Use. Cycles. Cabs, Buses, Trams.
MOTORS. Design and Management of a Motor Car.
AVIATION. Science and Management of Flying Machines.
RAILWAYS. The Management and Control of Railways.
SHIPBUILDING. Shipping. Design and Construction.

Group 9. Literature and Journalism

LITERATURE. A Survey of English Literature and Foreign Classics. The World's Great Books and their Writers.
JOURNALISM. How to Become a Journalist. A Guide to Newspaper Life. How to Write. The Journalist's System.
PRINTING. Composing by Hand and Machine—Linotype and Monotype. Stereotyping and Printing.
TYPE. Type Cutting and Founding.
ENGRAVING AND ETCHING. Blockmaking and Process Work.
LITHOGRAPHY. Printing from the Stone.
BOOKBINDING AND PUBLISHING. Binding and Issuing Books.

Group 10. Civil Service and Professions

CIVIL SERVICE. The Three Branches of the Public Services of the British Empire—Municipal, National, Imperial.
BANKING. The Whole Practice of Banking.
LAW. How to Become a Solicitor or Barrister.
MEDICINE. Training of a Doctor. Veterinary Surgeons. Dentists. Chemists and Druggists. Nurses.
INSURANCE. Health. Unemployment. Life. Fire. Accident.
AUCTIONEERING AND VALUING. Practical Training.
ESTATE AGENCY. Management of a Great Estate.
CHURCH. How to Enter the Ministry of all Denominations.
SCHOLASTIC. Teachers. Professors. Governesses. Tutors.
SECRETARIES. Institution Officials. Political Agents. Lecturers.
LIBRARIES. Management of Libraries. Cataloguing.
ARMY, NAVY MERCHANT SERVICE. How to Enter Them.

Group 11. Life and Mind

BIOLOGY. The Rise of Life. Evolution. Heredity.
PSYCHOLOGY. The Mind of Man.
SOCIOLOGY. Social Conditions. Welfare of Communities.
EUGENICS. Human Betterment and the Future of the Race.

Group 12. Business

BUSINESS. The Management of a Successful Business. System. Simple Political Economy.
SHOPKEEPING. All Kinds of Shops and Small Trades.
ADVERTISING. The Value of Advertising. How to Advertise. How to Write Advertisements. How to Get Them.

Group 13. Physics and Power

PHYSICS. The Science of Matter and Motion.
POWER. Sources and Uses of Power. Air. Water. Wind. Sun. Steam. Oil. Gas. For Electricity, see Group 16.
PRIME MOVERS. Structure and Management of all Engines.

Group 14. Building Trades

BUILDING. The Building Trades and Building Materials: their Manufacture and Use. Building a House. Excavating. Drainage. Bricks, Limes, and Cements. Bricklaying. Clay Wares. Reinforced Concrete. Masonry. Carpentry. Slates and Tiles. Plumbing. Joinery. Foundry and Smith's Work. Painting. Papering and Glazing. Heating. Lighting. Ventilation. Quantity Surveying.
WOOD-WORKING MACHINERY. The Machines Used in Working Wood: Sawing, Turning, Planing, Moulding.
CABINET-MAKING and UPHOLSTERING.

Group 15. Natural History

BOTANY. Flowers. Plants. Seeds. Trees. Ferns. Mosses. Fungi.
ZOOLOGY. Mammals. Birds. Fishes. Reptiles. Insects. Lower Forms of Life.
BACTERIOLOGY. The Story of Microbes. Bacteriology in Relation to Health and Industry.

Group 16. Electricity

ELECTRICITY. Its Development and Countless Applications. Electrical Engineering.
TELEGRAPHS AND TELEPHONES. The Instruments and How to Operate Them.
WIRELESS TRANSMISSION. The Main Systems and their Methods of Working.

Group 17. Music

OLD NOTATION AND TONIC SOLFA. Tuition in All Instruments. Orchestration.
ELOCUTION AND SINGING. The Voice and its Treatment.
MUSICAL INSTRUMENTS. Their Design and Manufacture.

Group 18. Manufactures

TEXTILES. The Textile Trades from Beginning to End. Cotton. Wool Silk. Hemp. Flax. Jute. Carpets.
LEATHER. The Leather Industry. Tanning. Boots and Shoes. Saddlery. Belting. Gloves. Sundry Leather Goods.
GLASS. Manufacture of All Kinds of Glass. Stained Glass.
EARTHENWARE. The Craft and Industry of Pottery.
PAPER. Papermaking of All Kinds.
RUBBER. The Source and Preparation of Rubber, and Manufacture of Rubber Goods.
TOBACCO. Cultivation and Manufacture. Tobacco Pipes.
FOOD SUPPLY. Milling. Breadmaking. Biscuits and Confectionery. Sugar. Condiments. Fruit. Fisheries. Food Preservation.
BEVERAGES. Tea. Coffee. Chocolate. Cocoa. Brewing. Wines and Ciders. Mineral Waters.
BASKETMAKING. CORK. WATTLE. CANE. BARKS. BRUSHES.

Group 19. Astronomy. Geology. Archæology

ASTRONOMY. The Universe as We Know It. Millions of Worlds. A Survey of the Solar System.
GEOLOGY. The Structure of the Earth. Petrology. Crystallography. Palæontology.
ARCHÆOLOGY. Buried History. The New Story of the Old World as Revealed by the Excavator.

Group 20. Mechanical Engineering

ENGINEERING. Applied Mechanics. Workshop Practice. Machine Tools. Machines and Appliances. Cranes.
DRAWING for Coppersmiths, Tinmen, and Boilermakers.

Group 21. Languages

LATIN. ENGLISH. FRENCH. GERMAN. SPANISH.

Group 22. Dress and Housekeeping

DRESS. Principles of Dressmaking. Underclothing. Tailoring. Millinery. Hatters. Furs and Feathers.
HOUSEKEEPING. Domestic Management. Servants and their Duties. Cookery. Laundry.

Group 23. Metals and Minerals

METALS. Metallurgy. Properties and Characteristics of Metals. Iron and Steel. Copper. Tin. Zinc. Precious Metals.
METAL MANUFACTURES. Arms and Ammunition. Cutlery. Clocks and Watches. Jewellery. Scientific Instruments.
MINERALS. Mineralogy. Properties and Characteristics of Minerals.
MINING. Coal. Gold. Diamonds. Tin.
QUARRYING. The Appliances and Processes of Extracting and Preparing Stone.
GAS. The Process of Manufacture.
PETROLEUM. Extraction and Refining Processes.

Group 24. Clerkship

ACCOUNTANCY. Complete Training. Bookkeeping.
SHORTHAND. Pitman's System, with Latest Improvements.
TYPEWRITING. Working and Management of All Machines.

Group 25. Mathematics

Arithmetic. Algebra. Simple Graphs. Euclid. Trigonometry.

THE BOOK ALL THE FAMILY READS

"I don't know what people did when father was a lad," writes a boy, "but whenever the Children's Magazine comes in he is always anxious to keep me at my lessons."

The Children's Magazine is the companion of the Self-Educator. No other magazine is read by so many people of all ages.

Here is the time-table of a day when the Children's Magazine comes home.

TIME-TABLE

9 a.m. Grandpa finds it on the breakfast table, and skims it—for two hours.

11 a.m. Auntie looks at an article, and decides to go through the whole magazine. Puts it down for lunch.

1.30 p.m. Grandma finds it, settles in her armchair, and goes slowly through it.

3 p.m. "An admirable thing for the children," says Uncle, picking it up for a peep which lasts two hours.

5 p.m. Mother looks through it over tea, lets her tea get cold, and puts it down in an hour, saying, "This should be called the Mother's Magazine."

6 p.m. Kitty picks it up, and is happy, when Father comes home. "Ah, the Children's Magazine! Nothing like this when I was a boy. Kitty and Tommy, get on with your lessons." Reads till eight.

AT BEDTIME

Tommy and Kitty: "Daddie, you know they call this the *Children's* Magazine?"

Daddie: "Ah, so they do! What a silly name! Now, then, off to bed, darlings."

THE CHILDREN'S MAGAZINE TELLS THE STORY OF THE WORLD FOR YOUR BOYS AND GIRLS, AND IS EDITED BY THE EDITOR OF THE SELF-EDUCATOR. IT IS READY ON THE FIFTEENTH OF EACH MONTH.

THE DEAD WORLD THAT CIRCLES THE EARTH

THE MOON AT THE AGE OF ABOUT SEVEN DAYS

From a photograph taken by M. Puiseux at the Paris Observatory

FACING PAGE 1021

Personality. Two Classes of Men. The Man who Gets Things Done. The Second in Command. Confidence.

CHARACTER AND PERSONALITY

To dogmatise about character would be as foolish as to dogmatise about the unknown and partially discovered laws of Nature. In the main it is a nebulous thing, as difficult of definition as the "fourth dimension," yet there is probably never a meeting of business men discussing methods and men in which the word "character" and "personality" are not freely used.

Suddenly to ask a man who is holding forth on the need of character or importance of personality what precisely he means by either phrase, might be to present a most awkward question. We use the words vaguely: they are thrown out to indicate roughly some idea common in our minds, and yet they may not always convey to others what they mean to ourselves. Knowing the difficulties of definition, I shall make no attempt here to do more than say what is in my mind when using these words as applied to men.

In a crude way, I take it that in ordinary talk one means pretty much the same thing by "character" as by "personality." The subtle distinction between the two is that the character of a man might be described as the inner qualities of his mind and nature, and his personality as the more obvious outward expression of these qualities. Anything more subtle than this is a matter for the philosopher, not for the straightforward dealer with men.

It seems to me that there can be no form of business activity into which personality does not enter and does not play its part in failure or success. Economists have claimed, and not without some show of reason, that this wonderful age of mechanism has tended to stamp out individuality. I am free to doubt this, for it seems to me that human personality is something stronger than all machinery; that it will express itself against all forces of circumstance. It is notorious that two men handling precisely similar machines can achieve widely different results. The individuality of man rises superior to the levelling influence of mechanism; personality is indestructible. This may sound suspiciously like platitude, but most platitudes have something of the virtue of truth itself, which is less characteristic of the dazzling paradox.

Two men of equal training and experience, up to a certain point in their careers may be equally valuable to their employer; yet he may see in one of them possibilities vastly in excess of those possessed by the other, and this arising entirely from some point of character. The wise employer makes a mental note of these possibilities, and when the occasion comes for testing the opinion he has formed he does so with confidence. If he has trained his powers of observation well, the test is most likely to prove successful, though I am far from claiming that there is any infallible touchstone of character.

Personality is, or ought to be, the eternal quest of the employer who is anxious to make the most of those who serve him. It is true that in many of the humbler offices where routine duties are all that is required of the worker it is little odds from the employer's immediate point of view what the personality of the worker may be; but at best this is a narrow view, and one I have never entertained. An employer is false to his own best interests, and, indeed, to the interests of society at large, who does not provide for the continual progress of his employees, either in his own or in *other* respective businesses.

In my opinion competition—within reasonable limits—is beneficial to all. Where there is room for one there is room for others, and where there is room for others there is room for more. That is why I have stigmatised as narrow-minded the employer who is content to leave his servants rusting in the little corners they happen to fit in his system, without regard to their individual possibilities in the larger world of business. The employer who seeks the development of his workpeople on the lines which their individual personalities most readily suggest is true to the best ideals of business.

It matters not whether his workpeople so encouraged outgrow the possibilities of his own employment and have to seek elsewhere for a larger outlet for those energies which he has fostered, as the general gain resulting to society will be reflected in its due degree on his own business; but the certainty is that his own business in the process will have benefited greatly. I think this is sound in economics; I am persuaded it is sound in practice.

First impressions are important, but not all-important. It is a commonplace that many men unconsciously conceal rather than expose their character in their personality, and have to be studied on several occasions before one can form a just and proper estimate of them. As Tennyson says of words that they "half reveal and half conceal the soul within," so one might say of personality; it half reveals and half conceals the inner character. But the very fact that A's personality is an open gate to his character, while B's is as a bolted door that requires some forcing, is of itself a help to the student of character. For A puts all his goods in his shop window, and gives a better first impression than B, who makes less display, but holds a larger reserve. The first impression of A might be entirely satisfactory, and later experience of him equally so, while the first impression of B might be disappointing and later experience relatively gratifying. Indeed, the chances are that the final impression of B would be more satisfactory that that of A, although intrinsically there might be little to choose between them. This is the result of the first impression of A having raised very high hopes of his ability, while the first impression of B left one in some doubt as to his qualities. All this tends to show that one has to be careful of these first impressions, and to have the courage to revise and modify them while maintaining fairness and justice to both A and B, who, it must always be remembered, may both have been natural and unaffected at the first interview. Truly, first impressions are very often lasting, and the curious instinct of divining character at first meeting—absolutely through the senses and by no effort of the mind—is a quality to be envied by all whose lot in life is to deal continually with many diverse types of human personality.

Roughly speaking, business men may be divided into two classes: those who do things and those who get things done. I have always thought that the Kaffir name for a certain great Englishman, "Motlôhodi," which is freely interpreted as "The man who gets things done," is one of the finest tributes ever paid to a public man. The man who is perfect in every detail of his work, who may be full of initiative, of resource, and the very embodiment of industry, but who only does things himself and has not the faculty for getting others to carry out his ideas and so to multiply his personality, is the lower of the two types of men regarded solely from the business point of view.

There are many men who can do things, but the men who can get things done are very few. It is merely a mathematical proposition to state that the man of the most admirable gifts who does his own work to perfection can never hope to achieve the same measure of success as the man who, with none of the other's mastery of detail and power of execution, can contrive by impressing upon his fellow-workers his conception of the things he wishes to have done, to make them become in a sense reproducers of his ideas, multipliers of his personality. It is given to some men to be able to say to others "Do this," and to others to do things superlatively well. Both have their success and their joy of work, but the stronger personalities are those that say "Do this" and get it done.

There is one detail which all business men who have had the direction of large enterprises must have had frequently to consider; and that is the question of the "second in command." At first blush it may be thought that this is a subject rather remote from personality, but it really strikes at the very core of character. There is no surer index of the weak man than his fear of having a colleague next in command who is as strong in character and clever in business capacity as himself. At the back of innumerable failures in business has been the fact that some one man who has climbed to a position of responsibility has been afraid of the competition of a skilled "second in command." Wherever there is unmistakable evidence of this disposition in a man of responsibility it should be counted as rather of the nature of a heavy item on the debit side of his character.

In the study of personality or character, evidence of confidence and enthusiasm is

of very great importance. Confidence is a fine thing; but even if it were three-fourths of success, the remaining fourth is indispensable; for, after all, three-fourths of success is not vastly better than failure. We are told by those who have studied the matter that the art of swimming is acquired slowly or quickly according as the would-be swimmer has confidence in himself. There is no doubt that, translated into the ordinary affairs of life, and particularly into the battle of business, this element of confidence also plays a notable part.

I have heard that one of the many freakish American plans for helping the ambitious towards success provides for certain morning exercises in which the student has to repeat aloud to himself—with, I suppose, varying degrees of emphasis—the words "I will succeed today," and in sitting down in his office chair to begin the day's work he is to pause for a moment and utter a final "I *will* succeed *today*." The notion is, I presume, that by telling himself that he will succeed he produces a sort of subconscious force that makes for success. We may describe it as the Dutch courage of confidence, but I gravely doubt that any man by taking thought can generate within himself the real spirit of confidence. It is something inborn, something that can be added to, and something very valuable if it is natural to the man.

Confidence at best, however, is only a factor in success, and is only one of many aspects of character. It may be as harmful to one man as it is helpful to another. If it be not backed up by common sense and reason, if it rest not on some basis of sound sober thought, then confidence may be a perilous possession. I suppose it is true that as many failures have been made by men who were confident of success as by men who were dubious and lacking confidence. I am even ready to believe that as many successes have been made by men who were so afraid of failure that they left no stone unturned to ensure success as by men who had simply the one splendid impulse of confidence in their success.

I think I have already hinted at some of the other personal qualities that reveal character, and the possession of which, together with confidence, would leave little room for doubt as to a man's personality; but of all the qualities worthy of admiration and calculated to tend successward, I should incline to place enthusiasm highest. This, too, is a characteristic whose presence may not imply certain other absolutely essential qualities. But enthusiasm is a thing that some personalities radiate, and often it covers a multitude of shortcomings

The self-confident person who lacks the ability to give his plans shape and direction only succeeds in presenting a personality that repels, that prevents others from co-operating with him towards his own success. But the man who is afire with enthusiasm for some enterprise which, single-handed, he could not direct and engineer to success, will often succeed by the mere contagion of his enthusiasm as it affects his colleagues in the enterprise. Enthusiasm is indeed a beautiful thing, and in any analysis of success I venture to think it would be found a much weightier factor than mere confidence. Nothing worth doing has ever been done without enthusiasm, and even when it is misdirected it is not necessarily vain.

One has to be careful, of course, in setting down these thoughts not to overlook the defects which so often accompany the merits. The "blind enthusiast" is a common phrase of our workaday speech which reminds us that there is such a thing as enthusiasm that outruns discretion. All who have fought in the battle of business know that even enthusiasm has failed at times to carry the day, and just as much as a man may burn with enthusiasm in the heat of the fight, so may he cool down in the chill of failure. Indeed, there are different kinds of enthusiasm. The only right kind is that which sees success ahead and works steadily towards it with a strong conviction of attainment, but if the opposing forces eventually prove too strong, does not give way to despair, but speedily generates a new enthusiasm for some fresh enterprise and conveniently dismisses from his mind the one that failed.

Very often enthusiasm implies a restless spirit, keen at the beginning of a venture but cooling soon after the excitement of the start. Confidence too frequently obscures the defects of the situation to be faced. Caution, on the other hand, is apt to paralyse enterprise, and mastery of detail to blind one to the broad issues that lead successward.

NORTHCLIFFE

HIGHLANDS AND WESTERN ISLES OF SCOTLAND

THE WESTERN COUNTIES OF SCOTLAND, SHOWING ITS RUGGED COASTLINE AND THE NUMEROUS LARGE AND SMALL ISLANDS IN THE ATLANTIC

This map is not exact in distance, but it gives an impression of the country. The light dotted lines represent steamship routes, and the heavy dotted lines show the boundaries of the counties.

The Orkneys and Shetlands. The Hebrides. The Highlands and Lowlands. Scottish Coalfields. Southern Uplands.

THE FACE OF SCOTLAND

Each region of the British Isles has its own character—inland or maritime, highland or lowland, agricultural, pastoral, or manufacturing, and each must be briefly described.

The Scottish Islands. In the Orkneys and Shetlands we are on the fringe of inhabited Britain, among a people mainly Scandinavian. Both groups number scores of islands, most of which are uninhabited. In the Shetlands, Mainland is the largest island; it is over 50 miles long, but so intersected by the sea that no place is more than four miles inland. Lerwick is the chief town. In all the islands the shores are wild and rocky, and the interior is a bleak, treeless moorland, feeding cattle, sheep, and small ponies. The climate is almost too wet and cool for agriculture, but some barley, oats, and potatoes are grown. Nearly every man is a fisherman, the herring fisheries being the most important. In the long winter nights the women knit fine shawls of the soft island wool for export. Life in the Orkneys is very similar to that in the Shetlands. Pomona is the largest island, and Kirkwall the largest town.

The Hebrides, off the west coast, are divided into the Outer Hebrides, of which the largest is Lewis, and the Inner Hebrides, with Skye in the north, Mull in the centre, Islay in the south, as well as many smaller islands.

Surrounded by stormy seas, with fierce currents running between the islands, it is natural that the fisheries, though important, should not be very profitable. The wet climate does not favour agriculture, and much of the interior is poor moorland, only fit for sheep or deer. In summer the beautiful sea and mountain scenery brings many tourists, who add something to the scanty resources of the islanders. Peat is the chief fuel, and oatmeal and fish form the staple diet. Simple habits prevail, and cottage industries are still carried on in the long winter nights. The hand-woven Harris tweeds are made in the south of Lewis, in the north-east of which is Stornoway, the chief town and fishing centre. Portree in Skye, Tobermory in Mull, and Bowmore in Islay are all tourist centres. Iona, with its relics of early Christianity, and Staffa, with Fingal's Cave, both west of Mull, are much visited in summer.

The North-Western Highlands. The map indicates the character of this region. Lying far north, where the summers are short and the winters long, and with little land under 1000 feet above the sea, the conditions of life must ever be severe, and population scanty. In the west, the mountains come down to the sea, which has drowned the lower valleys, forming fiords. These open to wild and lonely glens, often filled by long, narrow lakes, fed by innumerable mountain torrents, whose waters, browned by a peat soil, leap from boulder to boulder in wild beauty. An occasional sheep-farm or shooting lodge is the only sign of life, for this is the home of the sheep and deer, not of men. In the north-east is the lower tableland of Caithness, whose red sandstones, resembling those of Orkney, are largely quarried. The softer rock and lower elevation allow of some agriculture, but fishing and sheep farming are still the chief occupations. Bare moors, known as deer forests, are numerous, and the salmon fisheries in the streams bring tourists in summer. Towns, not all of which are in Caithness, include Thurso, Wick, Dornoch, Tain, Dingwall, Cromarty, and Beauly. The Cromarty Firth is an important naval station.

The Wonderful Valley of Glenmore. Two railways reach the west coast, one at Mallaig, from Fort William, at the southern end of Glenmore; one at the Kyle of Lochalsh, beyond Strome Ferry, from Inverness at the northern end of Glenmore. This wonderful natural rift, running from the Moray Firth to Loch Linnhe and the Firth of Lorne, divides the highlands into two parts. On either side of Glenmore—the Great Valley, or Glen—tower bare mountains, with here and there a glen opening to east or west between hillsides, which in autumn are glowing with bracken or purple with heather. In the floor of the glen are Lochs Ness, Oich, and Lochy. Across the alluvial flats between them a canal has been cut, converting Glenmore into the Caledonian Canal. At the north end is Inverness; at the south end of Loch Ness is Fort Augustus, in the centre of the waterway; and near the south end of the glen is Fort William, behind which are seen the precipitous flanks of huge Ben Nevis (4406 ft.), the highest point in the British Isles.

The South-West of the Highlands. This region of sea lochs and mountain glens, part of the South-Western Highlands, has a beauty all its own. It is inhabited only along the shores of the fiords, where fishing villages are numerous. It is most accessible by sea, for few roads and no railways are carried up its steep glens south of Oban. It is busy and prosperous in the short yachting and shooting season, but the winters are long and lonely. After Fort William, the chief town is Oban, on the Kerrera Sound, a centre of yachting and steamer traffic. This district is connected with the south by the West Highland and the Callander and Oban Railways. The former line from Mallaig and Fort William crosses the desolate moor of Rannoch to Loch Lomond, which opens a direct route south to Dumbarton and the Clyde. The other line runs from Oban round Loch

Awe to Loch Earn and by Strathyre and the Pass of Leny to Callander. The Lower Clyde, below Dumbarton, is a magnificent fiord, from which smaller fiords open to the north.

At its mouth is the hilly island of Bute, with Rothesay, on a magnificent bay, commanding one of the finest views in the world. This is the starting place for the famous Kyles of Bute, a chain of sounds opening to Loch Fyne, at the head of which is Inveraray. The western wall of Loch Fyne is formed by the long mountainous peninsula of Cantyre, across which the Crinan Canal gives a short route from Oban to Glasgow. East of Cantyre is Arran, with lofty, precipitous peaks, wild glens, and romantic views of mountain and sea. Brodick and Lamlash, the largest towns, are little more than villages.

The South-East or Grampian Highlands. These highlands, which lie south of Glenmore, and east of the valleys and lakes followed by the West Highland line, are the most rugged and inaccessible part of the British Isles. They are not, like the South-west Highlands, opened up by winding fiords, and the only natural routes are the Tay valley, opening to the south; the Dee valley, opening to the east; and the Spey valley, opening to the north. Between these is a bleak and lofty region, buried in snow in winter, across which the railways and roads are carried with great difficulty. Much of it consists of grouse moors and deer forests. Sheep farms are scattered among the hill pastures of the lower valleys, and some agriculture is possible where these open to the lowlands. Towns are found mostly in the valleys.

The Splendid Position of Perth. The southern margin of this great highland area, which descends steeply to the plain and from Perth, looks like a mountain range, is called the Grampian Mountains. In reality it is only the edge of a great plateau which it is convenient to call the Grampian Highlands. All the routes from the north converge on Perth on the Tay. From Stirling a route goes to Callander, past Lochs Vennacher and Achray, to the Trossachs Pass, Loch Katrine, and Loch Lomond, one of the finest tours in the Highlands. Crieff, situated farther north, commands similar routes. Perth, on the Tay, at the end of the Sidlaws, commands routes in all directions, and is the key of the Highlands. The main route to the north follows the Tay to Dunkeld. After receiving a branch from Loch Tay, it traverses the wild ravine of the Garry by the famous Pass of Killiecrankie, and crosses the divide to the Spey valley at a height of 1500 feet. This natural route between the Monadliath Mountains on the north-west, and the Lochnagar and Cairngorm Mountains on the south-east, is followed as far as Aviemore, through wild and desolate scenery.

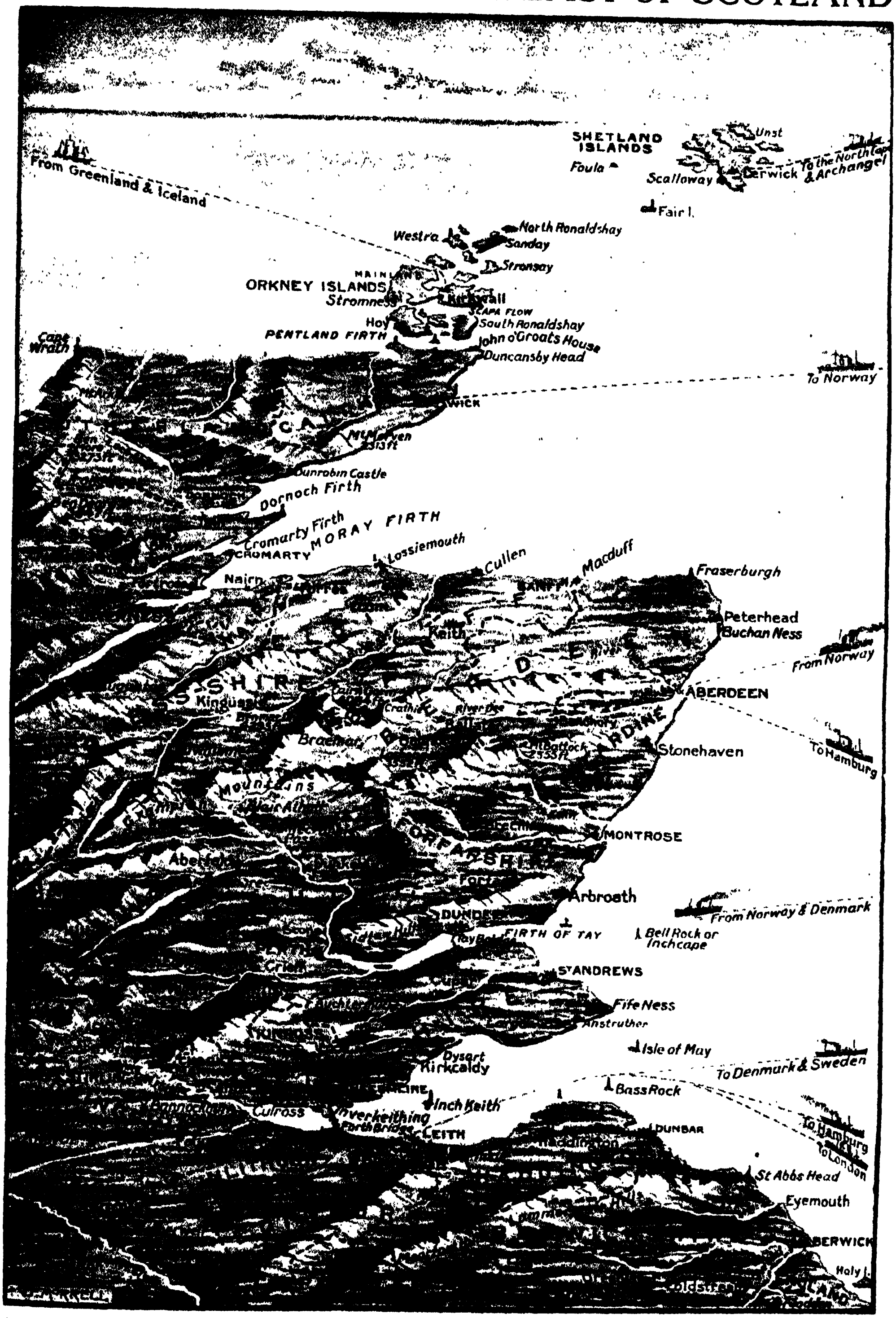
After Aviemore the main line strikes away from the Spey across the lower eastern end of the Monadliath Mountains to Inverness, while a branch continues by the Spey to the rich agricultural lowlands on the Moray Firth.

Towns in the South-East Highlands are numerous, the most important among them being Nairn, Forres, Elgin, Banff, and Fraserburgh; those on the coast are engaged in fishing and fish-curing. Many small rivers from the eastern slopes of the Highlands cross the north Aberdeen lowland, where Peterhead is the busiest town. Aberdeen, built where the valleys of the Don and Dee converge, has a university. It is a fishing and fish-curing centre, a busy port, shipping grey granite to the south, and has manufactures. A line follows the Dee valley to Ballater, near Balmoral, within reach of the magnificent scenery of the almost inaccessible Cairngorm and Lochnagar Mountains, the former separating it from the Spey valley. Many valleys, with towns at their mouths, open to the lowlands of Forfar, which form part of the Midland Plain. Montrose and Arbroath on the coast, and Forfar inland, are the largest towns immediately north of the Sidlaws.

The Midland Plain, or Lowlands. At the base of the southern escarpment of the Grampian Highlands extends Strathmore, a broad stretch of old red sandstone, with a deep and fertile soil. It is bounded to the south by a broken line of heights, known under various names, between which the rivers reach the sea. The Tay and Earn reach the Firth of Tay between the Sidlaw Hills of Forfar and the Ochil Hills of Fife. South of the former is the fertile Carse of Gowrie, with Dundee, manufacturing jute and marmalade, as its chief town. Here the Tay estuary is bridged. The Forth, which rises on Ben Lomond, broadens into the Firth of Forth, between the Ochils and the Campsie Hills. Stirling, with its towering castle rock, the lava plug which once filled the vent of a long-perished volcano, guards this important river, which here forms its famous links or windings. The Clyde, from the Southern Uplands, with fine falls near Lanark, becomes at Glasgow one of the greatest commerce-laden rivers in the world.

The Scottish Coalfields. South of the Renfrew Heights, which divide the Midland Plain into two parts, are some of the Scottish coalfields. The Ayrshire field, which lies west of the Renfrew Heights, ships much of its output from Troon and other ports to the manufacturing towns of the opposite coast of Ireland. Kilmarnock, manufacturing woollens, is the chief town of the Ayrshire field. The central, or Forth and Clyde field, extends up the Clyde as far south as Lanark, and as far east as the Forth estuary. Glasgow, built, like many other prosperous cities, at the lowest point where a navigable river can be bridged, is the centre of one of the busiest industrial districts in the world. It has immense shipbuilding and engineering works, chemical and other manufactures, and an enormous transatlantic trade. Both banks of the Clyde as far as Dumbarton on the right, and Greenock on the left, are lined with busy towns. Of the inland towns, Coatbridge, Motherwell, and Airdrie have mining and iron industries, and Paisley manufactures into thread the cotton brought to Glasgow. The eastern part of the coalfield, with fewer facilities for obtaining raw material

A BIRD'S-EYE VIEW OF THE EAST OF SCOTLAND



A PICTURE MAP OF THE EASTERN COUNTIES OF SCOTLAND, WITH THE ORKNEY AND SHETLAND ISLANDS, SHOWING THE MAIN PHYSICAL FEATURES

This map is not exact in distance, but it gives an impression of the country. The light dotted lines represent steamship routes, and the heavy dotted lines show the boundaries of the countie-

by sea, is less busy. Stirling makes tartans, carpets, and other woollens, and Falkirk has collieries, ironworks, and chemical manufactures. The coalfields of Fife and Midlothian are on opposite sides of the Forth estuary. On the former, Burntisland, Kirkcaldy, and Methil ship coal, Dunfermline manufactures linens, and Kirkcaldy linoleum.

Edinburgh and the Lothians. In Midlothian, the chief town is Edinburgh, the capital of Scotland. It is built where the Pentland Hills approach the sea, round a castle-crowned crag like that of Stirling. Edinburgh guards the routes south into England and west to the Clyde. It has a famous university and medical school. Among its industries paper-making, printing, and brewing are important. Its port is Leith, continuous with it, which ships much coal. Above Edinburgh is the great Forth Bridge across the estuary. In the neighbourhood of Edinburgh are collieries and oil shale works, and many paper-mills, worked by the streams coming down from the Pentlands. Fishing villages dot the southern shore of the estuary. Dunbar, at the base of the Lammermuirs, controls the route from England to Scotland round their eastern base.

The Southern Uplands. A line drawn from Dunbar to Girvan, on the Ayrshire coast, marks the northern limit of rocks older than those of the plain, but younger than those of the northern highlands. These form the Southern Uplands. The scenery is less picturesque than that of the highlands. Instead of bare, rocky peaks and precipices, the hills have rounded forms, and soil enough for coarse pastures, bare rock being seldom seen. The four river valleys, of the Clyde, Nith, Annan, and Tweed, must be noticed. That of the Clyde has already been described. The Nith valley, at the mouth of which is Dumfries, with woollen, iron, and leather manufactures, forms one of the main routes between Carlisle and Glasgow. West of the Nith the hills are wilder and the valleys more fertile. Kircudbrightshire is famous for its heather honey. Salmon fisheries are important in the Solway Firth. Sheep and cattle are kept throughout this region, the Galloway cattle being a famous dairy breed. East of the Nith is the Annan, giving a route to the Clyde valley. The railway crosses the divide at Beattock, in a sheep-farming district, with a great annual sale of Cheviot rams. The height at Beattock is nearly 1000 ft., and the surrounding hills rise to 2500 ft. East of the Annan route passes lead to Peebles, Selkirk, and the Tweed valley, which widens in the east to a considerable lowland. Its tributaries—Gala, Yarrow, Ettrick, Teviot, and others—drain a high, bleak region occupied by scattered sheep farms. The wool is manufactured in small towns in the valleys below—Peebles, Innerleithen, Galashiels, Selkirk, Hawick, and others—all of which are important market towns. Ruined abbeys, of which Melrose on the Tweed is the most famous, show how disastrous were the interminable English wars. Many old keeps and border castles tell the same tale, and have been immortalised by Sir Walter Scott. On the lower Tweed are Kelso, the centre of a rich agricultural district, and Berwick. on the English border, technically in England, The route from Carlisle to Edinburgh crosses the Southern Uplands by the Liddel, Tweed, Gala, and the Midlothian Esk valleys. That from Berwick skirts the eastern coast.

A. J. AND F. D. HERBERTSON

BEN NEVIS, THE HIGHEST MOUNTAIN IN THE BRITISH ISLES

National Variations of Romanesque Art Under the Dominating Influence of the Church

THE FORERUNNER OF GOTHIC ART

THE art of the Middle Ages may be divided into two periods: the Romanesque and the Gothic. The earlier of the two coincides with the troublous time after the fall of the Roman Empire, when the world power passed to the Northern States, and was essentially of a monastic character. The peoples were engaged in constant war and strife, and the cult of the arts and sciences was almost entirely in the hands of the religious bodies, whose main energy was directed towards the building of churches and monasteries.

Thus the Romanesque period was, above all, one of architecture, the other arts being pressed into its service as subordinate adjuncts; and the characteristics of the style which, as the name conveys, was based on the Roman model, can best be studied in such churches and buildings as have escaped decay or destruction.

The plan of the Romanesque church is based on that of the early Christian basilica; but the modifications gradually introduced in the plan soon transformed the entire style. The one characteristic feature which is retained through all phases of Romanesque architecture, and which is its chief distinguishing feature from the Gothic, is the round arch. The modifications of the plan include the lengthening of the choir and of the transept to form a cross-shape, and the abolition of the forecourt or atrium, which is either left out altogether or reduced to a small vestibule. It is only natural that the simultaneous evolution of the Romanesque style should have taken different forms in the different countries.

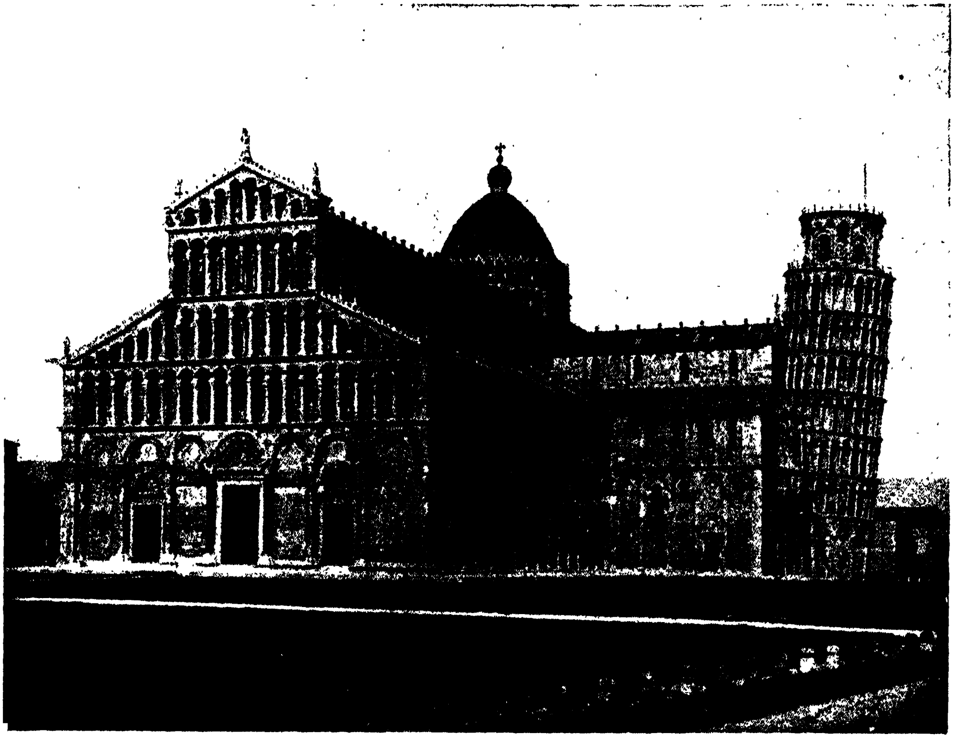
Thus, in Italy the clock tower remained an independent member of the building; whilst in Germany and France the two spires flanking the main porch, as an integral part of the architectural plan, became the customary device. In the Provence again, under Saracenic influence, the pointed arch was frequently adopted in the place of the semicircular arch.

In early Romanesque times the nave had generally a flat, wooden ceiling like the early basilica, which was first replaced by the barrel vault, and later by plain cross vaulting. This cross vaulting was first introduced in the narrower aisles, and for a long time the difficulties of spanning the loftier and wider nave were considered insuperable. The nave, being generally of about twice the width of the arches by which it is separated from the aisles, it was found necessary in the vaulting of the nave to carry the "groin-rib" across the width of two arches of the colonnade, so that the vaulting is supported by alternating columns, or rather pillars, since the new conditions necessitated a firmer support.

As a result, the harsh contrasts between the supporting and resting members disappeared, and gave way to flowing line and rhythmic articulation. To bring the width of each compartment of the vaulting into harmony with the arches of the colonnade (which had only half the width), a blind arch was frequently imposed over two of the arches, connecting two pillars in a semicircle which had its centre on the capital of the intermediate column.

Columns in the Romanesque period no longer followed any rules of proportion, and were on the whole more massive than in the classic period. As regards the capital, the typical form is a fanciful cubic shape which in an ingenious manner establishes a natural passing from the circular shaft to the square architrave. The exterior, too, is marked by its massiveness and preponderance of masonry, in contradistinction to the Gothic church, where the eye is caught by the lace-like traceries of windows, rose-windows, and pinnacles. In Italy, more particularly, the long, horizontal lines of the nave and the lower aisles, which are clearly marked on the exterior, give the character to the building; whereas in Gothic church architecture the eye is carried heavenwards by the perpendicular lines of the spires and pinnacles. The relief ornamentation consists of a conventional treatment of plant and animal forms, whilst the wall spaces of the interior, especially of the apse, are frequently decorated with fresco

THE FAMOUS CATHEDRAL & TOWER OF PISA

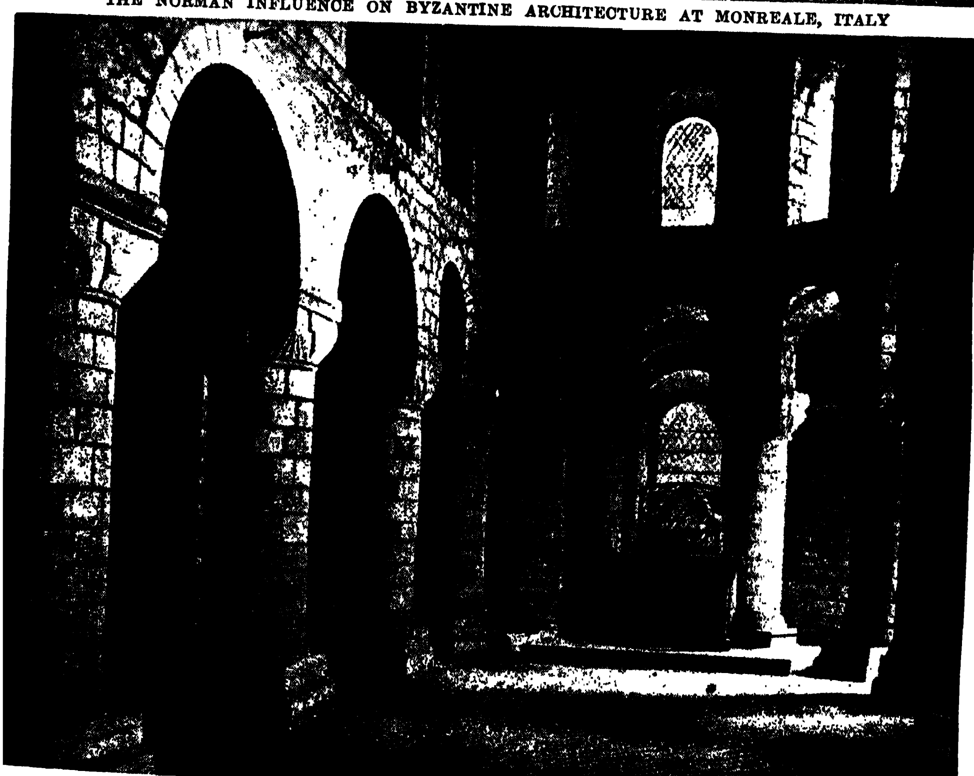


THE MOST FAMOUS BUILDING OF THE TWELFTH CENTURY IN ITALY—THE CATHEDRAL AT PISA

THE PALAZZO LOREDAN, ON THE GRAND CANAL, VENICE

THE NORMAN CONQUESTS IN ARCHITECTURE

THE NORMAN INFLUENCE ON BYZANTINE ARCHITECTURE AT MONREALE, ITALY



THE CHAPEL OF THE NORMAN KINGS IN THE TOWER OF LONDON

paintings. For baptisteries and mortuary chapels a circular or polygonal plan was generally adhered to, as during the early Christian period.

One of the earliest and most imposing works of Romanesque architecture in Italy is the Cathedral of Pisa, with its famous leaning tower and circular baptistery. The plan is of basilica type, with a nave flanked by two aisles on either side, a transept divided, as it were, into a nave and aisles by two colonnades, and terminating in apses, with the intersection of nave and transept crowned by a cupola. The exterior and the inner wall are built of alternate layers of blocks of white and green marble. The entire exterior is beautifully articulated by colonnades of blind arches on the ground floor, and arcades of free columns on the upper part. The cathedral was begun in 1063. The leaning tower owes its deviation of about 16 ft. from the perpendicular, in the first instance, to the sinking of the foundations, which took place in the course of its construction; but this unforeseen difficulty did not prevent the bold builders continuing the work, which has now endured for over eight centuries.

In Florence, San Miniato is the earliest and most exquisite example of Romanesque architecture, and is remarkable for its raised choir over a beautifully vaulted crypt. The walls are covered with beautiful marble incrustation in panels and bands of black and white. The interior is covered with a timber roof decorated with bright gold, green, red, and blue.

In Northern Italy the development of the Romanesque style was considerably influenced by that of Central Europe, and the details in particular lead up to the Gothic forms, though the campanile, or clock tower, even where it is not detached from the body of the church, never forms an integral part of the design. Brick was frequently used as building material, and very restricted use was made of exterior decoration. Frequently the articulation of the building, the division into nave and aisles, is not even suggested on the façade, and the galleries are restricted to the top of the gables and apses. Examples of this style abound in Lombardy and Northern Italy, among the most notable being San Zenone in Verona, San Michele in Pavia, and the Cathedral in Modena. Of secular buildings of the period the Palazzo Loredan and the Fondaco dei Turchi, in Venice, present perhaps the most typical examples.

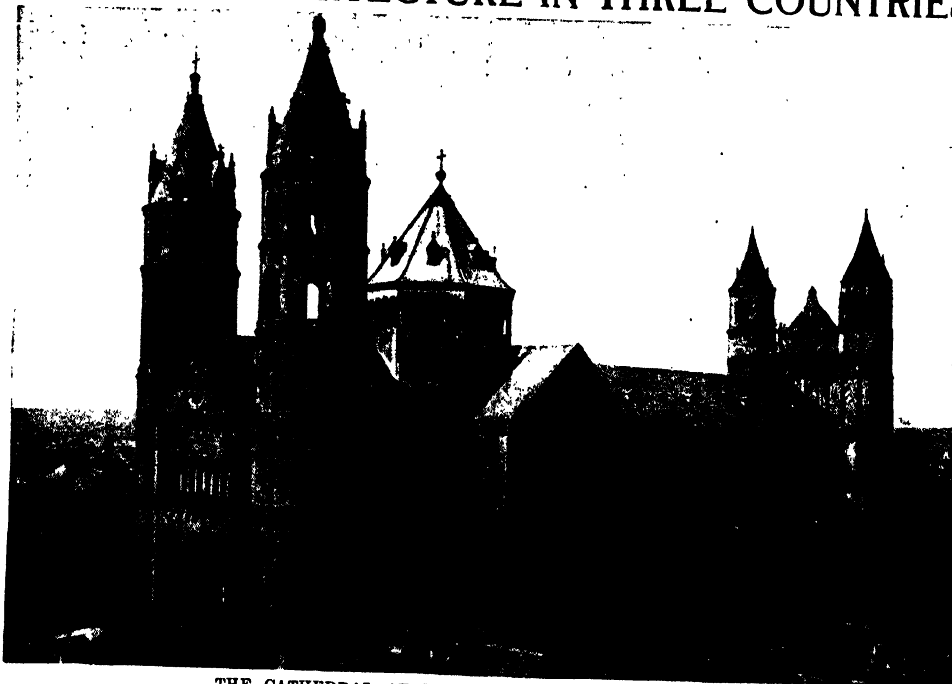
In Southern Italy and Sicily the Romanesque style was grafted by the Norman conquerors on the Byzantine and Mohammedan tradition which had taken firm root on this soil. The result was a curious mixture of a basilica plan, Byzantine mosaics and ornamentation, Saracenic pointed arches, and Romanesque towers, such as is to be found in the church of Monreale and in Palermo Cathedral.

In France, again, we have to distinguish between the South and the North. The South followed the tradition of classic architecture in construction and decorative detail. Barrel vaulting was extensively resorted to, the vault generally covering the entire length of the nave, whilst the aisles terminated in semi-barrel vaults, which counteracted the thrust of the central vault, leading it to the outer walls. The system necessitated the sacrifice of the clerestory windows, and the substitution of strong shafts or pillars for the columns. The chief monuments of this type are to be found in the Provence and the Dauphiné. Avignon Cathedral, St. Sernin, at Toulouse (end of eleventh century), and Arles Cathedral are among the most no able examples. The Romanesque churches of Burgundy and French Switzerland are very similar in plan.

In the North, the cool, bold, and clear spirit of the Normans left its impress on the architectural style of this race of conquerors, which is throughout logical and structurally sound. In the place of the barrel vault we find here generally cross vaulting. Two bold towers rise from the front of the churches, and, as a rule, another massive square tower crowns the intersection of the nave and transept. The ornamentation is very simple, and almost entirely of linear character—meanders, zigzag lines, and chessboard pattern; but towards the end of the period these motifs were very extensively employed, covering large surfaces on the porches, arcades, and interior walls. A notable example of this Norman-Romanesque style is the church of St. Etienne at Caen, built at the end of the eleventh century.

The Norman style came to England in the wake of William the Conqueror, and soon supplanted the earlier Saxon style, from which it adopted, however, the use of timber, especially for ceilings. Vaulted naves of this period are almost unknown.

NORMAN ARCHITECTURE IN THREE COUNTRIES



THE CATHEDRAL AT WORMS, IN SOUTHERN GERMANY

THE SOUTH AISLE, PETERBOROUGH CATHEDRAL

THE CRYPT OF SAN ZENONE, VERONA, ITALY

Romanesque architecture is exemplified in England and Northern France by the work of the Normans; and the style is therefore often called Norman

The crossing is generally crowned by a massive tower, which is frequently ornamented with arcadings. The ornamentation is particularly rich in the doorways; the columns are generally round, with square capitals, and very massive and heavy, as though they were intended to support a heavy vault. Most of the Norman English cathedrals have undergone numerous modifications at later periods, but those of Peterborough, Gloucester, Waltham, Winchester, and Norwich have retained much of their original Romanesque character, though Norwich and Durham have Gothic vaults, and Peterborough a Gothic west front and retro-choir. In London, Romanesque or Norman architecture is best represented by the round portion of the Temple Church, the Keep and St. John's Chapel in the Tower, and St. Bartholomew the Great, Smithfield.

In Germany, the Rhine provinces hold the finest examples of Romanesque architecture, which is here closely allied with that of Northern Italy. A most impressive feature is offered by the numerous octagonal and circular turrets, and the arcaded galleries with which the churches are adorned. The articulation is very clear and simple, and every member of the building is given just the necessary degree of prominence. Vaulting was first introduced in the Rhenish provinces, but only about half a century after its general adoption in France. Romanesque church buildings abound in almost every part of Germany, and we need only mention the cathedrals of Worms, Spires, Aix-la-Chapelle, Mayence, Treves, Bonn, and Regensburg.

Throughout Europe, wherever the Romanesque style took root, the artistic expression of the period was essentially architectural. It was a time of general, as opposed to individual, ideas, and the flourishing of sculpture and painting can only coincide with that liberty of the individual which was then practically non-existent. Then the practice of the fine arts was almost entirely in the hands of the Church, and had to follow strictly traditional lines. The chief object of art in the hands of the priests and monastic orders was edification and instruction, and the means by which this was achieved was adherence to conventional symbols.

The forms of antiquity had lost their natural grace and flow of line in the Byzantine period, and were handed over to the Romanesque craftsmen in this stiff and formal modification. A considerable stretch of time was needed before the Northern races could rediscover the classic spirit that lay concealed under this formalism, and before they could develop a new style upon this foundation. In subject matter, as in form, the ruling of the Church dominated Romanesque art, and secular subjects occur but on rare occasions, as in the famous Bayeux tapestry, in which William the Conqueror's wife gave a naïve pictorial record of the conquest of England by the Normans. But Christian symbolism in art was by no means confined to Scriptural representations, and, as we have already found in the paintings of the catacombs, the characters of ancient mythology were frequently repeated, though a new symbolical meaning was now attached to them. A solemn, dignified formalism prevails which favours the typical rather than the individual.

In plastic art, the Romanesque period is chiefly remarkable for the numerous beautifully executed ivory carvings, which have been preserved in considerable numbers, and constitute the most complete link that connects the classic with the Gothic period. The craftsmen of that era also excelled in bronze casting, and numerous church doors with figure reliefs still testify to their skill. The art of enamelling was extensively practised, particularly at Limoges, and constitutes, through its application to metal work in relief, a transition from painting to sculpture. The method employed by the Limoges workers (champlevé) differs from that of the Byzantines (cloisonné), in so far as the latter filled the enamels into compartments formed by gold wire soldered to the base, while the former hollowed out the ground so that the gold or gilt outlines, which divided the different colours, stood out in relief. Painting was entirely confined to the illumination of manuscripts and the decoration of church walls with conventionally-treated figures.

The striving for artistic freedom and new forms is clearly perceptible in the closing epoch of the Romanesque period, though for a long time it was kept down by the severity of the hierarchic tradition and by the rule of the Church. Only about the beginning of the thirteenth century, with the dawn of the Gothic epoch, did art attain to that individual expression which makes it a vital factor in the life of nations. P. G. KONODY

The Action of the Heart, Arteries, Capillaries, and Veins. Pulsation. Vascular Glands. The Lymphatic System.

THE STREAM OF LIFE

We have considered the whole system of vessels, large and small, that convey the blood to every part of the body, and examined the wonderful pump by means of which the life stream is propelled once round the body every minute. All this can, of course, be looked at after death; and if any student is interested enough to verify the facts we have described, and shall describe, in this course, an admirable way of doing so is to buy a skinned rabbit that has not had its internal organs removed, and then, with a common penknife and a pair of forceps, the leading facts of anatomy can, with little trouble, be clearly made out; and although the arrangement in a rabbit is not exactly that of a human being, it is quite near enough to serve all practical purposes.

The Blood in Circulation. But now we have to follow mentally what cannot be seen by dissection—and that is the blood in actual circulation through the body.

The best way is to begin with the heart, and follow the course of the blood through the various chambers there, bearing in mind at the outset one or two leading facts. The blood enters the heart on the right side, and finally leaves it for the body on the left. The right heart is always full of bluish, or venous, blood; the left of bright red, or arterial, blood.

The blood arrives at the right side of the heart by the two large veins from the upper and lower parts of the body. Just before the inferior vena cava, or lower vein, reaches the heart, it receives its fresh supply of food by a large vessel from the liver that opens into it; and just before the superior vena cava, or upper vein, reaches the heart, it receives all the chyle, or digested fat, together with the purified lymph, from the body, so that the venous blood which pours into the heart is not the same as that which left the capillaries, but has already received its fresh supplies of nourishment. All it now wants is the oxygen from the air to restore its bright colour.

The Heart an Automatic Pump. The blood enters the heart by the *right auricle*, and pours down through the open valve in the floor into the *right ventricle* below. As this fills with blood, the flaps of the valve—three in number (hence it is called the tricuspid valve, because it has three cusps, or flaps)—float up on the blood and close together gradually. When the right ventricle is quite full, the heart contracts forcibly, and all the blood is forced out of the ventricle, through another valve with three flaps, along a short artery called the pulmonary, or lung artery, because it takes the blood to the lungs to be charged with fresh air. It then passes through the innumerable lung capillaries.

When the blood has received its supply of oxygen, it returns by *four vessels*, called the pulmonary veins, to the *left auricle*. It pours through the valve in the floor (which is called the mitral valve, because it is like a bishop's mitre, and has only two flaps, or cusps) into the *left ventricle*. As this fills, the cusps of the mitral valve are floated up and closed. The heart then contracts vigorously (at the same time as on the right side) by sudden muscular action of the walls (which are over half an inch thick) and forces all the blood through another valve with three flaps, called the aortic valve, into the aorta. [See WHAT IS THE PULSE—page 953.]

We thus see there are two principal circulations—one called the systematic, or *greater*, *circulation*, that circulates through the system or body; and the other the pulmonary, or *lesser*, *circulation*, that circulates through the lungs. In the former the blood *loses* oxygen, gains *carbonic acid*, and becomes dark and impure; in the latter the blood *loses carbonic acid*, gains *oxygen*, and becomes bright and pure.

The Power of the Heart. The strength of the beat of the left ventricle is double that of the right, and the whole force exerted by the heart is equal to 120 tons lifted one foot high, or the heart's own weight raised 20,000 ft. every hour. The greatest height an active man can raise himself is 1000 ft. an hour; a locomotive can raise itself nearly 3000 ft., but the heart raises itself higher than Mont Blanc—a truly remarkable capacity for work. There is an idea that the heart is more incessantly at work than other organs. Such is not the case, but the periods of rest alternate much more rapidly. All working parts of the body have their intervals of rest—the brain when we sleep; the stomach, eyelids, and diaphragm at shorter intervals.

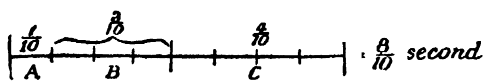
If the whole circle of the heart's action be completed in $\frac{8}{10}$ of a second, half of this is rest, as is represented in [**38**]. The contraction of the heart is called the *systole*, the rest the *diastole*.

The movements of the heart are mainly caused by three sets of ganglia in the heart itself. With proper care, a heart can therefore beat when out of the body altogether, and even when cut in three pieces, each of which includes one of these ganglia or nerve centres.

Arterial Circulation. Passing on now to the course of the blood in the arteries, we must remember that we have not here to deal with a series of rigid pipes, but highly elastic tubes. This elasticity is a very important property in more ways than one. In the first place, the beat of the heart or the injection of four tablespoonfuls of blood into the aorta is intermittent, and takes place about seventy times a minute, or at least

every second. This force, if an artery were a rigid tube like a gas-pipe. would draw the blood along in jerks at about 200 ft. a second. As it is, the force first of all distends the elastic artery so that we can feel it swelling beneath the finger at the wrists, and can also often notice it with the eye there, and at the temples [33]. Then, in the intervals between the beats, the contraction of the over-stretched artery still keeps up the pressure on the blood, and forces it along the vessel, converting by this means an intermittent propelling power of 200 ft. a second into a steady flow of about one foot a second. which is the average arterial speed of the blood until the capillaries are reached. We have stated that if the arterial calibre be represented by a tube one inch in diameter, that of the united capillaries would be about two feet, or nearly 600 times as great.

The Rush of the Blood Checked. Here, then, the rush of the blood is completely checked. It is like a river flowing into a lake, and not only into a lake, but into a network of tiny channels equal in size to a lake, and involving loss of power by friction against their million walls. All this reduces the blood speed from one foot a second to one inch a minute. On this retardation, as we have shown, our life depends. The air and food cannot be brought



38. ONE BEAT OF THE HEART

A. Auricular Systole = $\frac{1}{10}$ sec. *B*. Ventricular Systole = $\frac{3}{10}$ sec. *C*. Diastole, or pause = $\frac{4}{10}$ sec.

too quickly to the populous cell towns; but once there it is carried slowly from door to door that each may take his share, and all be satisfied. So far, from all we have said, it might be supposed that the process is simply mechanical; A well-made pump beating ever at 70 strokes a minute forces the blood into miles of tiny tubes, through which it circulates at a fixed rate. But such is not the case. In the first place the circulation in the arterial system depends, of course, upon the heart's beat; but this is by no means uniform nor equally forcible, for in its turn it is controlled from the lower brain. The control may be partly reflex—that is, the result of stimuli; but those who have thought more on the subject are convinced that even in reflex action there is something more than mechanism; there is the directing agent of mind.

Action of the Capillaries. Once, however, the capillaries are reached, the power that controls the movement of the blood is no longer the heart force with which it is propelled, but the opening or closing of the channels through which it has to flow. There is, as we shall see when we study the nervous system, and as we have briefly pointed out in speaking of assimilation, a central power that controls absolutely the opening and closing of the miles of capillaries in the body, so that they are incessantly varying according to the changing needs of the economy, and its requirements not only of food but of heat. For we must ever remember that this great circulation of hot food through the body not only feeds it, but to some extent warms it.

We cannot here go into the wonderful way in which whole tracts of capillaries are thus incessantly being opened and closed according to the body's needs.

The Blood in the Veins. When we come to the veins we find for the first time the circulation begins to be in difficulties. It is easy to drive the blood from the heart to the capillaries, say, of the great toe; the difficulty is to get it back again. It is in every sense uphill work, for the force of the heart is well-nigh spent as far as direct impulse goes, owing to the passage through the capillaries; but still a certain compulsion from behind remains to help the blood, now venous in colour and quality, back to the heart.

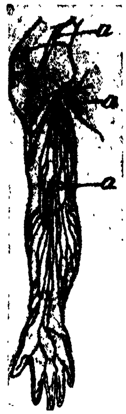
The second help that comes into play arises from the fact that the walls of the veins are thinner than the arteries, and as they are placed between the large muscles in many cases, muscular contraction in the exercise of arms and legs squeezes these veins so forcibly as almost to act as another pump. Of course, a moment's reflection will show that squeezing a pipe alone does not propel the contents—it simply forces some portion back and some a little forward. Valves are required that open toward the heart, but cannot be opened backward, and these, as we have seen, the veins possess; so that every squeeze can only move the blood in one direction, and that is toward the heart. Here we see the value of exercise in aiding the venous circulation. Without it the venous blood tends to stagnate, and as a result all the vital processes are retarded as the circulation becomes enfeebled.

Respiration Aids the Circulation. The next help the circulation gets is from the respiration, in which the pressure on the large blood-vessels and heart is withdrawn, and then the blood is sucked up toward that organ. The factors, then, that bring the blood back from the capillaries to the heart are: (1) The heart's beat; (2) the thinness of the veins; (3) the squeezing by muscle contraction; (4) the valves; (5) respiration. Thus in almost one minute the blood flows from the left to the right side of the heart.

We may here state that generally the influences that slow down the circulation are cold, digitalis, and the pneumogastric nerve, whereas heat, atropine, and the sympathetic nerve accelerate it. The vaso-motor nerve opens and closes the capillaries, and these act harmoniously, not only with arteries, but with the nerves controlling the heart.

When the Blood leaves the Heart. Blood, when it leaves the heart, has its choice of one of five courses. The *shortest* is round the walls of the heart itself, to nourish its muscles, starting from the left side and returning through the right veins. This is called the *coronary* circulation. The *next* longer is from the pulmonary artery in the right side of the heart through the lungs and back to the left side of the heart by the four pulmonary veins. This is called the

pulmonary circulation. The *second* longer is from the left side of the heart through the walls of the digestive organs and kidneys, receiving the food and carrying it into the liver and also getting rid of any refuse, and flowing back to the right side of the heart. This is called the *digestive* circulation. The *third* longer is from the left side of the heart through the brain by special capillaries and veins that cannot close, which we shall describe later, and so back to the right side of the heart. This is called the *cerebral* circulation. The *last* and longest is through every part of the body, and this is the *systemic* circulation, and has been already described.



39. THE LYMPHATIC VESSELS IN THE ARM
(*a*) Lymphatic glands

What is the Pulse? The pulse is not the actual flow of the blood, which would certainly appear to be intermittent, as indeed it is, when it spurts out of a cut artery. In the closed artery, however, it is not, as we have shown, intermittent, but is steady, owing to the pressure of the blood in front and the give of the elastic arterial walls. The pulse is the wave sent along the blood by the beat of the heart, by the forcing into the aorta of the fresh supply of blood. This wave passes down the blood-stream, stretching the wall of the artery as it travels along twenty-eight times as fast as the blood itself flows. The pulse, therefore, at the wrist is almost simultaneous with the beat of the heart, which it could not possibly be if it were the flow of blood that caused it.

Besides its elasticity, the artery has also its muscular coat, which in the smaller vessels adjusts the amount of blood to the state of the capillaries (whether open or shut), so that there may be no sudden block. This nice adaptation of the size of the vessel to the amount of blood in it is called "tone," and the loss of tone in an artery shows either languor of central controlling power (nerve exhaustion), or failure of elasticity (due to age or disease), or the formation in the arterial walls of hard plates (as in gout), all interfering with the regularity of the circulation.

A pulse is to be found not only at the wrist, but wherever an artery is near enough to the surface for the wave of the pulse to be felt or seen, as at the temples, the ankles, and so on.

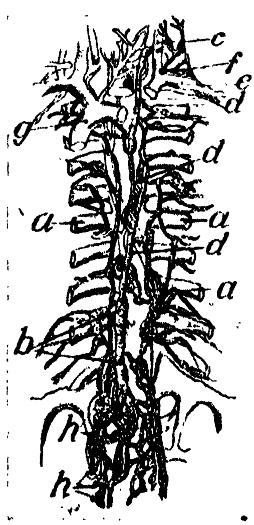
The Vascular Glands. As indirectly connected with the vascular system, we may here consider the vascular glands, which include the spleen, the thyroid and the thymus glands, and the suprarenal capsules.

The *spleen* is about the size and shape of the palm of the owner's hand, and is situated beneath the ninth, tenth, and eleventh ribs in the left side beneath the diaphragm. Its convex side is outward and its concave is in close proximity with the tail of the pancreas. It is of a deep red colour, full of blood, and weighs about half a pound. It is credited with many functions, one being that of a storehouse of peptones. The red corpuscles of the blood are also said to be born here and introduced into the blood in great numbers, and then broken up and taken out when they want to die. The spleen is greatly enlarged in ague and other diseases.

The *thyroid gland* consists of two lobes, united by a band and lying in front of the larnyx, or throat. It weighs normally 1½ ounces; but, like the spleen, may be greatly enlarged in disease. It contains a gummy material, the purport of which is not readily ascertained. When it is diseased, the mental faculties seem affected. The Derbyshire neck or goitre is an enlargement of this gland.

The *thymus gland* is an inch long, lying lower down at birth on each side of the windpipe, but disappearing very early in life. It may form red corpuscles, like the spleen.

The *suprarenal capsules* are two small bodies like cocked hats, one on the top of each kidney, and seem to serve a remarkable purpose. The extract obtained from them has a marvellous power of contracting capillaries and stopping the flow of blood, and is now extensively used in arresting hæmorrhage. Its power is wonderful, and we have nothing so efficacious in drugs. When these suprarenal capsules are diseased, the whole skin gets the colour of bronze. There is no doubt that they exercise a powerful influence over the economy of the body, and further discoveries may tell us exactly what this influence is.



40. THORACIC DUCT
(*a*) Ribs; (*b*) receptaculum chyli; (*c*) left jugular vein; (*d*) trunk of thoracic duct; (*e*) left subclavian vein; (*f*) junction of these two veins, showing entrance of thoracic duct; (*g*) superior vena cava; (*h*) lymphatic glands

The Lymphatic System. We now turn to a brief description of the lymphatic system, a small portion of which only has been touched upon in describing the digestion of fat.

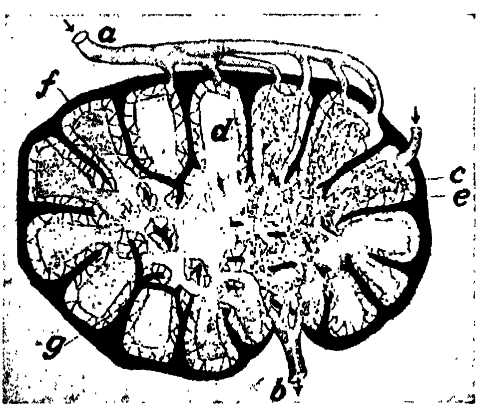
It will be remembered that at the outset we pointed out that throughout the body there are three descriptions of vessels coloured by the fluid they contain red, blue, and white. The red and blue we have considered — they convey the arterial and the venous blood. The white or colourless are the lymphatics, which form a system almost as large as the true vascular system, of which they are an appendage, and with which they are everywhere connected. We must understand, then, that within the whole of the tissues of the body surrounding all the capillaries, and existing wherever there are no blood-vessels, is a vast network of tubes containing the liquid drainage of the body, which flows

through ll those vessels, always toward the heart. The lymph capillaries collect into large lymphatics, and eventually enter two trunks, the right thoracic duct, which is small, and the left thoracic duct, which is very much larger, and which carries all the fat from the food; these enter the veins on each side of the root of the neck. Just as all the body cells and tissues are being continually irrigated by capillaries, whose thin walls allow the fluid to ooze through, so they are constantly being drained of the surplus fluid by the lymphatics [**39**]. Besides this general use, the lymphatics have at least two other special functions.

1. They act in the intestines by the agency of the lacteals as absorbents of "fat" food and in the formation of chyle.

2. In some tissues they form the sole source of nourishment, as in the cornea of the eye, and in many connective tissues which have no blood circulation.

The whole system may be regarded as a necessary appendage to the vascular system, although we have treated part of it under the head of absorption in order to complete the history of food digestion. The lymphatics that begin as capillaries round the blood-vessels have very thin and irregular walls, and often appear mere channels hollowed out in the surrounding tissues. The lymph is the agent in conveying the oxygen and food from the blood capillaries, which they surround, to the body cells, as well as in conveying the major part of the excreta, CO_2, urea and so on, from these into the blood. It is the middleman between the tissues and the blood.



41. SECTION OF A LYMPHATIC GLAND
(*a*) Afferent & (*b*) efferent lymphatics; (*c*) lymphoid tissue; (*d*) cortical substance; (*e*) lymph-path; (*f*) fibrous capsule sending divisions into (*g*) the substance of the gland

Movement of the Lymph. The movement of the lymph toward the heart is first due to muscular pressure and very numerous valves. The collapsible lymphatics, whether among the voluntary muscles of the neck or the unstriped muscles of the intestine, have their contents therefore propelled in one direction. A second force is the direct act of the muscles surrounding each lacteal in the villi, by which, when full, their contents are ejected into the vessels beneath, valves again preventing their return. A third force is the inspiratory movement of the chest (as in the veins) which both squeezes fluid into the lymphatics and sucks the fluid of the large ducts into the blood-stream.

The lymphatics of the body, with the exception of some on the right side, but including all the lacteals, discharge their contents—after passing through numerous lymphatic glands on the way—into a large reservoir about 2 in. long, called the *receptaculum chyli* [**40**], lying in the abdomen at the lower part of the spine on the left side. From here a stout tube, as thick as a goose-quill and about 18 in. in length, called the *left thoracic duct*, leads right up the left side, and empties its contents at the juncture of the neck and arm (jugular and subclavian veins), thence to be carried to the right side of the heart.

The Police of the Body. Nearly all the lymph before entering the blood has to pass through one or more lymphatic glands. These are found in great numbers in the trunk of the body, in the neck, armpit, and groin, but not farther down the limbs than the elbow or knee. These glands are somewhat the shape of small beans, lying right across the path of the lymphatics, with the convex side outward or downward, along which the lymphatics enter, while the lymph leaves it at the hilum, or depression, on the other side by one or two larger vessels [**41**].

The lymphatic glands may be said to represent the police of the body, and every suspicious substance that enters the body finds its way to them sooner or later, and is there detained. They stop, as far as they are able, the circulation of all poisons in the system; but for them a poisoned finger would infallibly infect the whole body. Yet, thanks to a small gland at the bend of the elbow, or, if this fail, the extensive chain of glands in the armpit, the poison is arrested and destroyed. Sometimes the head or throat or ear or mouth is poisoned, and then it is that the poison is arrested and stopped and the life is saved by the lymphatic gland in the neck or throat; the glands swell and get painful, and we feel the lumps, which tell us the glands have done their work well. They are arranged all over the body at what may be called strategic points, and their value to the body cannot be exaggerated.

In cancer of the breast, for instance, in the early stages, when the poison is slight, it is stopped from entering the blood-stream by the glands in the armpit, which receive and destroy the poison, becoming enlarged and inflamed in the process. Should, however, the poison be allowed to progress undetected, there comes a time when its volume becomes too great, and it gets past them into the blood, and is there carried all over the body, and other centres of cancer are formed. These lymphatic glands are filled with white corpuscles, similar to those in the blood, and it is these that destroy the poisons by breaking them up and reducing them to their elements. All the drainage of the body, therefore, before it is poured into the blood, is carefully purified, much in the same way as impure water may be purified by passing it through a filter.

A. T. SCHOFIELD

Grass and Hay Production. Manuring and Irrigation.
Constituents of a Good Crop. Haymaking and Thatching.

PASTURES, MEADOWS, AND HAY

A *pasture* is permanent grass-land used for stock. *Meadow* land, on the other hand, equally permanent, is land which is usually mown, and subsequently grazed, although, where it is again intended to mow the crop, stock should not remain upon it after the first week in February. It is often customary to mow a meadow in alternate years, grazing during the years between. Pasture land, upon which stock are fed with cake or corn, may improve in quality from year to year; for the manure they produce is all retained, while its value is improved owing to the extra food consumed. Thus the animals may return to the land a larger amount of fertilising matter than they extract from it. Further, the continual treading of stock keeps it compact, and induces the finer grasses to grow more vigorously.

If the herbage of two fields of identical character—the one being a pasture and the other a meadow—is examined, it will be noticed that it differs in variety and character. If, too, one part of a meadow is skilfully manured from year to year, and the other part unmanured, it will be recognised that a great change has been effected in the composition of the herbage. On the unmanured land the plants grown will be in greater variety; there will be more weeds and fewer grasses and clover. On the manured land the number of weed plants will be diminished, while the number of clovers and grasses will be increased.

The Improvement of Meadows. Where meadows are mown annually, they may still be enabled to improve in quality under a regular and well-devised system of manuring; the soil will thus increase in its fertilising value, while both the quantity and the quality of herbage will improve. Over a period of years, heavy manuring upon experimental plots at Rothamsted resulted in the increase of the hay crop to some 3½ tons per acre, whereas, where no manure was employed, the crop only just exceeded 1¼ tons. Again, over a period of seventeen years, the total quantity of hay produced by the employment of large dressings of superphosphate, nitrate of soda, sulphate of ammonia, sulphate of potash, and sulphate of soda reached from 62 to 72 cwt. per acre, while the addition of silicate of soda increased the crop to 85 cwt.

Manuring and Hay. To these facts we may add that the composition of hay, from a feeding point of view, is also changed where manuring is systematic. For example, the employment of farmyard dung is followed by a marked increase in the composition of the crop in potash and phosphoric acid and a decrease in nitrogen and lime. We have already shown that the varieties of plant growing on manured land are reduced in number. At Rothamsted, while the grasses proper never formed less than some 50 per cent. of the entire herbage, they reached on one plot 99 per cent. The leguminous, or clover, herbage never exceeded 40 per cent., but in one instance there was positively no clover at all. Again, the remaining herbage, chiefly consisting of weeds, was so large upon one plot that it reached 40 per cent., and so small upon another that it did not reach 1 per cent. If, therefore, by the intensive farming of grass-land weed plants can be produced and clovers increased to the extent to which these figures point, it is obvious that the benefit to the farmer from the point of view of quality may be as great as that from the point of view of quantity.

When Grass-land is Profitable. Grass-land can make no profitable return unless it is well cultivated. There are tens of thousands of acres within easy distance of the metropolis which do not make a gross return of £5 a year; and yet, under other systems of cultivation, this same land is equal to the production of ordinary crops worth at least double the money. In many cases market gardeners and nurserymen very largely exceed this figure, and there is little doubt that in some as much as £1000 per acre is returned per annum by the aid of glass on the same class of soil.

The growth of grass for hay on heavy land is best stimulated by annual dressings of dung and artificial manures; 5 tons of dung with ½ cwt. of nitrate of soda and 2 cwt. each of kainite and superphosphate, or 4 cwt. of basic slag—the latter where the land is in need of lime—will quickly improve the poorest grass-fields, and, as year succeeds year, convert land which is almost barren into a comparatively luxuriant pasture or meadow. For ordinary purposes, meadow land in fairly good condition may be maintained by the annual application of 1 cwt. of nitrate of soda with 3 cwt. of superphosphate, or 5 cwt. of basic slag.

A pasture is not so easily exhausted as a meadow from which the crop is annually removed, and for this reason it is seldom manured. Grazing promotes the growth of the finer grasses, and the diminution of those of a coarser nature. The best pastures are in the lowlands, especially in river valleys, on rich marshes and alluvial soils; and here it is customary to feed off the crops with cattle. On the other hand, the poorer pastures are on the uplands, of which the downs are an example, and here sheep are employed with the same object, but it is seldom that we hear of either upland or lowland pastures being manured with dung

or the various artificial mixtures. Owing to the shortness of the roots of the grasses, and their consequently diminished power of extracting mineral foods, it is essential that, from time to time, the chief mineral fertilisers, potash and the phosphates, should be supplied if the land is to produce good crops. If nitrogenous manure is employed, the grasses will respond to it, but at the expense of the clovers, which are of high value as food, unless phosphatic manure forms part of the dressing.

To Get the Best from Land. Although the average British hay crop is only 23·6 cwt., and the average English crop 24 cwt., a 1½-ton crop corresponding to five tons of grass, it must not be supposed that it is impossible to exceed this quantity on soil of average quality. It is customary among farmers to depreciate the value of the land they occupy, but there is very little land in this country which is farmed for a livelihood which could not be immensely improved, and which would not grow much larger crops by good management.

What do we mean by this term? Simply that the grass must be fed with manure, the fields in which it grows kept in rational condition, the drains kept open, the ditches cleaned out, the fences maintained, and the most obnoxious weeds, such as the thistle and the dock, permanently removed—for time and manure alone will cause a suppression of weeds of a less marked character. In the early spring grassland needs harrowing, by which means moss is pulled up, the soil aerated, embedded stones brought to the surface for picking, the droppings of cattle spread, and the land prepared for broadcasting artificial manure. Before rolling—a very necessary operation, for grasses like a solid bed—stones must be picked up and carted away, and mole-hills and ant-hills levelled. A field is then ready for the scythe as soon as the crop is grown.

Irrigation. Grassland is occasionally irrigated and maintained as a water-meadow, but the cost of preparation is considerable, hence the system is unpopular. Under a normal system of irrigation the water is turned on to the land, over which it runs through channels made for the purpose during late autumn and winter, when, owing in part to the fact that the water is moving, and in part to the further fact that it is charged with oxygen, the grass is induced to grow during cold weather. In spring the water is turned off, preparatory to the growth and harvesting of the crop, after which the land is again irrigated, that a second growth may be encouraged for feeding stock in autumn.

Laying down Land to Grass. Many of our permanent pastures have been under grass from prehistoric times. Grass-land, however, is frequently ploughed up, and planted with arable crops; but it is provided in most leases and agreements that the ploughing of permanent pasture is at the peril of the tenant, who is heavily penalised. It is much more common, however, to lay land down to permanent pasture, although some years must elapse before it can be regarded as first-rate, however well the work may be managed. Preferably the crop in the previous year should be roots or potatoes. An opportunity is thus given for both cleaning and manuring the land. If the root crop consists of turnips, it may be fed off by sheep which are well supplied with cake and corn. In this way the droppings will further enrich the land, and still better prepare it for nourishing the young grass plants in the following year. In some cases land intended for grass is bare-fallowed—that is, it is cleaned and no crop is grown.

In all cases success depends upon the cleanliness of the land, sufficiently deep ploughing, fine tilth, a firm bed, and good seed. Care should be taken, especially where sheep feed off a turnip crop, that the manure they have dropped should be kept near the surface, so that deep ploughing should have preceded the sowing of the turnips, and subsequent ploughing should be shallow. This will ensure a firm and yet sufficiently fine seed-bed. The surface cannot be too fine, nor, subsequent to seeding, too compact.

Necessary Precautions. Many experienced farmers prefer to sow grass and clover seeds for permanent pasture in a wheat crop, especially for the reason that, owing to the lapse of months since the wheat was sown, the bed will be firm. If, before sowing, the wheat is hand-hoed—although this is a costly operation—and subsequently harrowed in fine weather for the destruction of small weed plants, a grass seed-bed will be prepared. The seed may be sown with the barrow, as elsewhere described, covered in with very light harrows, and subsequently rolled to complete the process.

It is probable, however, that the majority of skilled farmers sow their grass seeds in spring corn—barley or oats; but whatever the practice, the suppression of weeds, the provision of fine surface tilth, and a compact seed-bed are imperative. It is obvious that the seeds should not only be of high germinating power, but of great purity. In the chapter on grasses (see page 574) will be found suggestions for seed mixtures. The seed should be sown and the whole operation completed in fine weather, tramping on a grass seed-bed in wet weather, especially if the soil is heavy, being disastrous.

The Nature and Yield of Hay. Hay is produced from the mixed herbage of the meadow—from clover, mixtures of clover and particular grasses, from rye grasses, timothy grass, both of which are occasionally sown alone, from lucerne and sainfoin—by the aid of the sun and the wind. When green oats, rye, or vetches are cut and dried in a similar manner, they are also often described as hay.

The dried grass of the meadow is known as meadow hay; hay of other kinds is usually described as mixture where the plants composing it are mixed, or by the name of the particular plant which has been cut. Hay is chiefly employed as a food for horses, cows, and sheep. Growers within reasonable distances of large

THE FINAL STAGE OF THE HAY HARVEST

BUILDING A HAYSTACK

towns send their best hay to market in trusses of 56 lb. each, 36 trusses forming a load. The trussed hay which has been pressed weighs, volume for volume, 50 per cent. more than hay trussed by hand. When hay is cheap, it returns a very small profit to the grower, the average English yield being only 24 cwt. to the acre in the case of meadow hay, and 29 cwt. in the case of clover and other artificial grasses. When less than 50s. a load is realised for a good sample it is wiser to feed the crop to stock on the farm. In grass counties, as in the West of England, hay forms the chief winter ration of the cow and the flock; in arable counties meadow hay is but little grown, the cattle being chiefly fed upon roots, straw, cake, and corn.

Qualities of Good Hay. The best hay is produced from early cut grass. The great majority of farmers prefer to cut later in the hope of obtaining a greater weight per acre; but this extra weight, tangible though small, is accompanied by inferiority in the quality. The seeds are in large part formed in late-cut grass, and, although small, contain the chief feeding properties of the plant, but they are largely shed. What therefore remains in stem and leaf is tough, stringy, and little better than straw. Good hay should not only be highly nutritious, but fragrant, green, and tender, and this may be secured while the grass is still young and succulent. When grass is cut early, a larger and much more valuable after-growth is obtained, while the work of the farm is advanced. On the contrary, when it is cut late, not only does the quality suffer, and consequently the market value of the crop, but the after-growth in dry seasons becomes very scanty. The fragrance of hay depends partly upon the grasses of which it is composed, the skill exercised in making, and the proper heating in the stack. Greenness is secured chiefly by wind-drying. When the sun is powerful, hay is easily bleached unless it is quickly handled and carried, but even then the colour is not so perfect as when it is dried chiefly by the aid of a warm wind. There are many buyers who prefer brown hay— that is, hay which has been sun-dried and properly heated in the stack.

Effect of Rain and Time. Both colour and fragrance as well as feeding value are lost where hay has been wetted by rain, or when it is carried and stacked before it is sufficiently dry. If carried when too dry, fragrance and succulence are lost altogether with colour and flavour. Rain, however, is the greatest enemy to hay, inasmuch as it not only washes out the soluble albuminoids and other feeding materials, but there is a danger of mould in the rick. Old hay is fuller in fragrance and deeper in colour than new hay, and as with time it settles in the rick it weighs more per cubic foot. Apart from the points to which we have referred, the quality of hay depends upon the herbage from which it is produced. There should, for example, be no plantain, Yorkshire fog, dock, knapweed, and little of the inferior grasses. In all samples of meadow hay, clovers should form a large proportion. The feeding value of hay may be estimated from the following analyses

ANALYSES OF VARIOUS HAY CROPS

CROP	Water	Ash	Organic Matter	Digestible Matter			Albuminoid ratio
				Albuminoids	Carbohydrate	Fat	
	Percentages						As 1 to
Meadow Hay							
Poor	14·3	5·0	80·7	3·4	34·9	0 5	10·6
Good	15·0	7·0	78·0	7·4	41·7	1·3	6·1
Red Clover							
Poor	15·0	5·1	79·9	5·7	37·9	1·0	7·1
Good	16·5	7·0	76·5	10·7	37·6	2·1	4·0
Lucerne (good)..	16·5	6·8	76·7	12·3	31·4	1·0	2·8
Sainfoin	16·7	6·2	77·1	7·6	35·8	1·4	5·2
Trifolium incarnatum	16·7	5·1	78·2	6·2	34·9	1·4	6·2
Rye grass	14·3	6 5	79 2	5·1	35·3	0·8	7·3

Chemical Constituents of Hay. According to Warington—a good authority—a crop of meadow hay weighing 1½ tons contains 49 lb. of nitrogen, 50·9 lb. of potash, 32 lb. of lime, and 12·3 lb. of phosphoric acid; while a two-ton crop of red clover hay contains 98 lb. of nitrogen, 83·4 lb. of potash, 90 lb. of lime and 24·9 lb. of phosphoric acid. Thus the hay crop removes from the soil as much nitrogen and a great deal more potash than a crop of either wheat, barley, or oats, and a crop of clover removes nearly twice as much nitrogen, more than twice as much potash, and slightly more phosphoric acid than either of these cereal crops. The same chemist points out that a crop of meadow grass weighing five tons and capable of producing 1½ tons of hay contains 2613 lb. of combustible material—carbon, hydrogen, nitrogen (49 lb.), oxygen, and sulphur —and 209 lb. of mineral matter (ash), chiefly potash, lime, and silica, the balance being water. From these figures we can practically gauge the manurial value of hay as compared with other foods. Taking cotton cake as representing 1000, clover hay is placed at 345, and meadow hay at 235. Thus, weight for weight, meadow hay of medium quality is practically equal to the cereals, and much superior to the cereal straws, and mature clover hay is superior to either, chiefly owing to its very considerable richness in nitrogen and potash.

Cutting the Crop. In making clover hay it is important to collect the crop before the leaves have become too brittle, inasmuch as they break up by handling, to the great loss of the farmer. It should be a rule in cutting to mow no more than can be mastered should rain threaten. A crop had better be cut late than made in wet weather, when it is too easily destroyed. Hay under hand should be no larger in quantity than can be put into the cock at very short notice. In this form hay is practically safe from destruction, unless wet weather continues. On the return of the sun, the cocks should be moved or opened, not only that the hay itself, but the ground upon which it has stood,

may be dried. In parts of the north of Britain it is common to cover the haycocks with a compressed paper cap or shield. In other parts, where wet weather prevails, the hay is made into small stacks weighing about half a ton. These stacks are skilfully loaded upon lorries when fit to carry, and removed bodily to the rick, on to the top of which they are elevated.

Mowing. Hay was formerly cut by the scythe, but in these latter days it is almost universally mown by a machine which practically covers an acre in an hour. The scythe makes cleaner work and damages the hay less, but mowers are now seldom to be found, and even where they are necessary the wages they require are much too large to permit of the practice being continued. Where a crop of grass is light, and the weather fine, it is often dried in a few hours, drawn into windrows with a *horse-rake*, and carted to the rick without any hand or machine work whatever. A good crop, however, after lying in the swathe sufficiently long for the upper surface to be partially dried, is turned over by men armed with forks, or by the modern implement known as the *swathe-turner*. In due course the partially made hay is then shaken out by the men or by hay *tedders*, drawn by one horse and driven by a boy.

Raking into Windrows. It is subsequently raked into windrows, and when, in the judgment of the farmer, it is fit for the rick, the carts are loaded, it is drawn to the stack-side, and either lifted by hand, by a needle, or a pair of gripping irons fixed on a pulley, or by the commonly used elevators. Hay in the windrow, or even before windrows have been made, if it is fit, is by many advanced or progressive farmers dragged to the rick by an American sweep drawn by a pair of horses, so that hauling either by cart or waggon is unnecessary. In some cases, too, an implement which is attached to a waggon is employed to take up hay as it passes along the windrows, but the former plan may be regarded as the better.

Loading. Under ordinary circumstances, the hay is loaded into carts or waggons by men known as pitchers, one on either side, two loaders being employed on a waggon and one on a cart. In this case each vehicle is followed by rakers drawing a hand-drag, and subsequently by the horse-rake, by the aid of which the field is thoroughly cleared. In all these matters judgment is required, not only to prevent partial destruction of the crop, but to ensure quality.

Stacking. A stack of hay varies in weight per cubic foot in proportion to its age, its composition, how far it has heated, and in accordance with the part from which it is cut. Thus, in the centre of a rick, hay weighs much more than at the top or the outsides. When it is well heated, fermented, or sweated, from eight to ten cubic yards will weigh a ton, more being required in new hay than in old, or in loose hay than in that which has well settled down. Thus, experience is required both in selling and buying; it is consequently wiser for the inexperienced to sell by the ton rather than by the stack.

Hay Barns. Instead of being built in stacks or ricks, hay is sometimes built in hay barns. These are usually constructed of iron standards supporting corrugated galvanised iron roofs. Sometimes, however, the structures are of wood with boarded roofs, each board being slightly grooved near each edge and placed from $\frac{1}{4}$ to $\frac{1}{2}$ in. from its neighbour. If hay barns are costly, they are of great economical value, for the hay is out of danger immediately it is under cover, which is not the case where the stacks are built in the open—in spite of using waterproof sheets—until the thatch has been laid on.

Thatching. It is wise to prepare the thatch before the haymaking season begins. Thatching straw should be long and strong, and the produce of the wheat crop. As the straw is required, it is placed in loose heaps and well wetted. It is next drawn in yelms, or small bundles, which are carried by the assistant to the thatcher, and laid on one by one, the work beginning at the eaves and finishing at the ridge. In some districts split hazel rods are employed for keeping the thatch in position. These rods are pointed at each end, twisted and bent in the centre, and grip the straw as they are thrust into the hay on the roof, like a hairpin. In other cases, the stakes are simply media on which the thatching twine is bound to keep the thatch in its place.

Thatching is an operation which needs considerable practice and skill, good workmen being extremely scarce. It is obvious that before thatching begins the rick should have settled, and that the roof should be well raked, even, and solid, for where there are depressions, or settlements, after thatching is completed, rainwater finds its way into the hay. It is specially important that the ends of the roof should be thatched extra tight, and well finished, or wind may remove the thatch and expose the hay to damage. Thatch should be a foot thick, in which case the wheat straw required will be nearly 5 cwt. per square of 100 ft.

Cost of Cutting and Binding. The cost of cutting and binding hay for market varies from 3s. to 4s. per load, averaging in round numbers 1d. a truss, the sum usually paid for the rough hay left on the farm. Clover hay is frequently bound with straw bands; this improves it appearance, and is more economical. Hay growers adjacent to large cities usually load their carts over night, the men leaving home in time to reach the market early on the following morning. In the various hay markets hay is sold on behalf of the owner by salesmen, who are paid by commission. They should be instructed to sell all consignments in the market, and never to send them direct to customers.

Board of Agriculture. During the haymaking season some assistance may be obtained by subscribing for daily telegrams forecasting the weather, and supplied at a small charge by the Board of Agriculture. But in the present state of our knowledge it is not wise to place too implicit a faith in forecasts.

JAMES LONG

Mixtures and Compounds. Atoms and Molecules. Atomic and Molecular Weight. Fixed and Multiple Proportions.

WHAT WE KNOW OF THE ATOM

To understand the real meaning of the table on p. 842, we must consider at length the *atomic theory*, which may be described as the logical basis of modern chemistry. The atomic theory regards matter as being built up of minute particles, which are called atoms, a name which literally means "uncut" or indivisible; and it assumes that the difference between one element and another —the difference, say, between gold and oxygen—is due to a difference in the nature of the atoms in each case.

Further, we assume that every atom of gold is exactly the same as all other atoms of gold, every atom of carbon exactly the same as all other atoms of carbon, and that this holds true whether the carbon be situated in the sun or in the human body, or in a comet or anywhere else. An *element* or elementary substance is one which consists of an indefinite number of atoms of the same kind. A *compound* consists of atoms of at least two kinds.

Are we to say, then, that a compound is simply a mixture? This is very far from being the case. Let us take familiar instances, air and water. The air is a mixture of gases—that is to say, a mixture of gaseous elements. These elements retain their own characteristic properties. The atoms of any one of these elements may go about in each other's company, but not in the company of the atoms of any other element of the mixture.

Atomic Companionships. Now, the essential character of a compound is that the atoms of one element go about in the company of the atoms of one or more *other* elements. Among the elements in the air, for instance, are oxygen and nitrogen. These are mixed, but not combined. But the substance we call water also consists of two gases—oxygen and hydrogen—yet it displays none of the properties that we attribute to either of these elements, nor does it display a sort of average or blend between them. It is totally different.

Indeed, this case furnishes us with a particularly good instance of the difference between a compound and a mixture. It is quite an easy thing to measure out a certain quantity of hydrogen and a certain quantity of oxygen, and to mix them together in a tube.

Compounds and Mixtures. The result is simply a mixture of two transparent gases. It is not in the least like water, has none of the properties of water, and, in short, is not water; yet water consists of these two elements in exactly the same proportions as those in which they are present in the tube in question. This can be readily proved by simply passing an electric spark through the tube. The result is that the gases disappear, and there is found in their place a drop or two of water. This drop of water consists of the very gases that were present in the mixture, and can, if necessary, be decomposed, with the reproduction of the mixture as before. What, then, constitutes the essential difference—a difference which, in point of fact, is very great—between a mixture of oxygen and hydrogen on the one hand and a compound of oxygen and hydrogen on the other hand?

Molecules. In order to answer this question, we must consider a new conception which is represented by the word *molecule* literally, a little mass. This word used often to be employed when atoms were meant, but we must sharply distinguish between the modern uses of these two terms.

Let us take, for instance, the gas hydrogen, which we believe to be composed of a number of atoms, all exactly similar. We find reason to believe that these atoms do not go about singly, but that they pair with one another, and each pair of hydrogen atoms constitutes a little system of its own, which we now call a molecule. In the case of the mixture of hydrogen and oxygen, we should find, if our eyes were keen enough, simply a collection of molecules, consisting either of two hydrogen atoms linked together, or of two oxygen atoms linked together. But if we made a similar inspection of the water which is formed when a spark is passed through this mixture, we should find the essential difference between a mixture and a compound. The mixture was simply a mixture of molecules of hydrogen and molecules of oxygen—each molecule, as we have said, consisting of two similar atoms; but in the compound, just because it is a compound and not a mixture, there is no such mixture of molecules.

The Molecule of Water. All the molecules of a compound are of the same kind, just as all the molecules of an element are of the same kind; but whereas the molecules of an element are composed of similar atoms, the molecules of a compound are formed of dissimilar atoms. Whereas the mixture of hydrogen and oxygen consisted of a number of molecules containing two atoms of hydrogen and a number of molecules containing two atoms of oxygen, the compound called water formed from that mixture contains only one kind of molecule, compounded of atoms of oxygen and atoms of hydrogen, while no molecules consisting only of hydrogen atoms or only of oxygen atoms would be found in it.

Now these facts may be very simply expressed by the judicious use of the symbols which we have noted in our table of the elements. We may say that the mixture consisted of a number

of H_2 molecules and a number of O_2 molecules —the two standing for the number of atoms in each molecule; but in the compound there are no H_2 or O_2 molecules. The molecules are all of one kind, and each consists of two atoms of hydrogen and one atom of oxygen. We express this construction of the molecule of water by the formula H_2O. That is the formula of water, and it expresses the fact that each molecule of water consists of two atoms of hydrogen and one atom of oxygen. Perhaps the formula would be more intelligible if it was written H_2O_1, but the $_1$ is never printed. It is understood that when the symbol of an element occurs without any figure after it, *one* atom of that element is indicated.

An Unstable Compound. The reader will very probably ask why it is that one atom of oxygen should combine with two of hydrogen. Why not one with one, or two with two? That question raises many important considerations, which will be discussed later; but we may here point out in passing that the combination of two atoms of oxygen with two atoms of hydrogen is known, and yields a compound called Peroxide of Hydrogen. This was discovered by Thériard in the year 1818, and this chemist considered it to be oxidised water, as when it is heated it freely decomposes into oxygen and water. As a matter of fact, it is a very unstable compound, as it contains, so to speak, one atom of oxygen in each molecule more than is comfortable, and hence it is very apt to lose this superfluous oxygen, which, when it goes, leaves H_2O, or water, behind. This property of giving off oxygen endows peroxide of hydrogen with useful properties. It bleaches many vegetable colours, and is also used in solution for restoring oil-paintings.

Among other purposes, it is often applied to the hair for the purpose of lightening its colour. It produces a characteristic yellow colour—"peroxide hair"—which is due to the fact that the oxygen given off from the H_2O_2 enters into combination with the dark pigment of the hair, and produces one of lighter colour.

Atoms in Pairs. Let us return now to the consideration of the molecules of an element —molecules consisting of similar atoms, as distinguished from the molecules of a compound, which consist of dissimilar atoms. There are some elements the atoms of which go about singly. Mercury and zinc are examples. In the great majority of elements the atoms go about in pairs. We have seen that this is so in the case of oxygen and hydrogen. But the precise number of atoms in the molecules of elements varies with circumstances. Let us consider, for instance, the peroxide of hydrogen, H_2O_2, of which we have spoken. We have said that it owes its use in bleaching hair to the fact that it gives off oxygen, which combines with and alters the hair pigment; but the reader will object that the hair is always in contact with the oxygen of the air. Why does not that bleach the pigment? A very satisfactory answer to this question can be obtained.

Let us consider the case of the atoms of oxygen in the air. Each of them is in combination with one of its fellows, thus forming a molecule of oxygen, and is, so to speak, satisfied. It has no desire to seek other partnerships (of course, the reader will understand that we are using symbolical ways of talking; these desires and satisfactions are now being explained in terms of electrical forces). The atoms of oxygen forming the molecules that surround the hair do not attack the hair pigment, because they are satisfied with each other.

The Release of an Element. But let us imagine that we can watch what happens to a molecule of peroxide of hydrogen, H_2O_2. As we have seen, this molecule contains one atom of oxygen too many for comfort—or, to use a less symbolical term, too many for *stability* and the extra atom of oxygen constantly tends to escape from the molecule, leaving behind a molecule of water—a molecule so stable that men studied chemistry for centuries before they discovered that it could be broken up, and that water is not an element.

We see clearly, now, it is one atom of oxygen that leaves the molecule of H_2O_2, but it is the peculiarity of an atom of oxygen, like nearly all atoms, that it must have a partner. As a rule, we may imagine the atoms of oxygen that leave two adjacent molecules of peroxide of hydrogen to unite with each other, and thus form a molecule of oxygen, O_2; but if, just at the moment of their escape, there are any other substances present with whose atoms the atoms of oxygen can combine, instead of merely combining with each other, they are apt to combine with these other substances, and this is why the peroxide of hydrogen can bleach the hair by giving oxygen to it, while the oxygen of the air is quite unable to do so.

When the atoms of any element are caught, so to speak, in the act of combining with each other—that is to say, in the act of seeking companions—the element is said to be in the *nascent* state, which literally means the state of being born. (The term is not really a good one, for we now attach a very real and different meaning to the birth of an element—as the birth of helium from radium.) It is when nascent that the chemical properties of the element are most strikingly manifest. In the language of chemistry, then, we say that peroxide of hydrogen, H_2O_2, bleaches the hair in virtue of the fact that it liberates *nascent oxygen*; and the reader now understands why nascent oxygen should be more chemically active than oxygen that is not nascent—that is to say, than oxygen the atoms of which have already settled down to a humdrum existence in stable pairs.

The Properties of Ozone. We have seen, then, that the atoms of oxygen may sometimes be caught *single*. The formula for oxygen at such a moment would be O (the $_1$ being understood); and we have seen that, as a rule, the atoms go about in *pairs*, indicated by the formula O_2. But we further discover that, under certain conditions, the atoms go

about in *trios*, in which case the formula of the oxygen must be O_3, indicating that each molecule consists of three atoms. A special name has been given to this modification of oxygen, which is called *ozone*.

Now, just as peroxide of hydrogen, H_2O_2, is an unstable substance, always eager to get rid of its superfluous oxygen and relapse into the more familiar substance water, so, similarly, ozone, O_3, is an unstable substance, always anxious to get rid of its superfluous atom of oxygen, and settle down into the commoner kind of oxygen O_2. Whenever there is any opportunity for getting rid of the superfluous atom of oxygen to anything that will have it, the ozone seizes the chance. Indeed, two molecules of ozone left by themselves will very soon turn into three molecules of ordinary oxygen.

A Chemical Equation. Such a change may be expressed in the first chemical equation to which we shall introduce the reader:

$$2\,O_3 = 3\,O_2$$

This simply expresses the idea that two atoms liberated from two adjacent molecules of ozone have united with each other to form a third atom of oxygen, which is added to the two atoms of oxygen which were left by their departure. The equation is a true equation, as the reader will see when he applies the test of ascertaining whether all the atoms named on the one side of the equation, and no more, are accounted for on the other side of the equation. It is a true equation, because it represents six atoms on each side. Of course, the reader will understand that we have been talking in very metaphorical language, since no one can possibly see, or experiment with, two molecules of ozone or any other substance; but there is no doubt that our metaphor corresponds with the actual fact.

Now, we do not know of any form of oxygen in which the molecules consist of more than three atoms; but there are certain substances which possess four atoms to the molecule. Of these, phosphorus and arsenic are examples. Thus the formula for phosphorus must not be written P or P_2, but P_4. When we come to examine the behaviour of atoms of sulphur, we find that, at certain temperatures, they go about in pairs, and the formula for sulphur at such temperatures must be S_2; but at other temperatures they seem to go about in sixes, and the formula for sulphur at these temperatures must be S_6. We can now readily understand the relation of what is called *molecular weight* to *atomic weight*.

Molecular and Atomic Weight. The *molecular weight* of any body containing, say, four atoms to the molecule will plainly be four times the atomic weight; but, surely, before discussing molecular weight, we must understand what we really mean by atomic weight.

Perhaps the most fundamental character of matter is its mass. [See PHYSICS.] We have seen, of course, that we have no absolute measurement for mass, but can merely estimate the mass of one substance as compared with that of another. We have already seen that the mass of the hydrogen atom, being the lightest known, used to be taken as the standard of measurement, but that now there is a tendency to prefer oxygen as the standard, and to represent the weight of the oxygen atom as 16. Plainly, in such case, the molecular weight of oxygen must be 32; the molecular weight of ozone must be 48; the molecular weight of hydrogen must be 2; and the molecular weight of water, H_2O, must be $18 = 1 + 1 + 16$.

The Law of Fixed Proportions. What, then, are the chemical facts that may be explained on this atomic theory, which asserts that matter consists of atoms of different kinds, the atoms of each element being of a constant and definite weight—weight being the means by which we express the amount of matter in, or the mass of, the atom which we weigh? The first law which may be explained on the atomic theory, and on no other which has been suggested, is the law of *fixity of proportions*, or *fixed proportions*.

This law asserts that every chemical compound —assuming, of course, that it is pure—always possesses the same constitution—that is to say, is always composed of the same fixed proportions of the elements that go to compose it. Let us take, for instance, the case of the simple compound called water. From whatever source we obtain a specimen of water, and under whatever conditions we examine it, it is invariably found that, when the water is decomposed, eight-ninths of its weight is composed of oxygen and one-ninth of hydrogen. What is true of water is true of every other compound. If the compound is what it professes to be, it is invariably found to contain absolutely fixed proportions by weight of the different elements that go to compose it.

An Experimental Fact. Observe here the difference between a mixture and a compound. Oxygen and hydrogen may be mixed in any proportion; but in the *compound* of them called water the proportion is absolutely constant — one-ninth hydrogen, eight-ninths oxygen.

Now, this experimental fact as to the fixed proportions (by weight) of the elements in water tallies precisely with the facts we have observed as to the relative weight of oxygen and hydrogen, for we found that oxygen is approximately sixteen times as heavy as hydrogen; and, on the atomic theory, we asserted that water consists of a number of molecules, each of which contains two atoms of hydrogen and one of oxygen. If that theory were true, every molecule of water would consist of hydrogen to the extent of one-ninth part of its weight, whilst oxygen would supply the other eight-ninths, since the one atom of oxygen weighs sixteen and the two atoms of hydrogen taken together weigh two. If, then, water is made up of a number of such molecules, any quantity of water that we examine at any time should similarly prove to consist of one-ninth of

hydrogen and eight-ninths of oxygen by weight; and that is what is found.

The Law of Multiple Proportions. The second law which is explained by John Dalton's theory, and by no other that has been suggested, is the law of *multiple proportions.* This may be simply illustrated by taking two familiar substances, such as nitrogen and oxygen. There are five known compounds of nitrogen and oxygen. When we come to weigh the proportions of nitrogen and oxygen in these five compounds, we find that they may be arranged in a series of a very significant character. If we represent the weight of nitrogen on the top line and the weight of oxygen on the bottom line, we find that the ratios in the five compounds are as follows:

$$\frac{14}{8} \quad \frac{14}{16} \quad \frac{14}{24} \quad \frac{14}{32} \quad \frac{14}{40}$$

Now, 14 is the atomic weight of nitrogen, and 16 is the atomic weight of oxygen. Thus, on the atomic theory, we can very readily explain the fact that there are five compounds of oxygen and nitrogen in which the weights of the two constituents are arranged in multiple proportion, 8, 16, 24, and so on. We can explain the first compound, in which we found the ratio of nitrogen to oxygen as 14 to 8, on the atomic theory, by asserting that this compound consists of the union of two atoms of nitrogen to one of oxygen. This is obvious, if for 14 to 8 we read 28 to 16, a ratio which suggests the composition we have stated. The formula of this substance is N_2O. It is known as laughing-gas, and whenever we analyse laughing-gas we find that it consists of nitrogen and oxygen in the proportions by weight of 28 and 16. The next compound of oxygen and nitrogen, in which the weights of the two elements are in the ratio of 14 to 16, must plainly consist of molecules which have one atom each of oxygen and nitrogen. Its formula is N O. Similarly, the next compound and the two next show a simple increase in the ratio of oxygen to nitrogen.

Five Kinds of Molecules. We have to conclude that two atoms of nitrogen unite respectively with one, two, three, four and five atoms of oxygen, and form these five different kinds of molecules, whose compositions illustrate the law of multiple proportions, and can be explained only by the atomic theory. The five formulæ are as follows: N_2O, N_2O_2, N_2O_3, N_2O_4, N_2O_5—and these formulæ illustrate the relations of the substances; but it is more accurate to write N O and N O_2 instead of N_2O_2 and N_2O_4, since it is probable that the simpler formulæ represent the actual way in which the atoms go about; though the double formulæ, when inserted in their place in the series, make more obvious the nature of the relation between the five compounds. If the reader will turn back to the ratios $\frac{14}{8}$, etc., which we gave in starting, he will see how perfectly they are explained on the atomic theory. If that theory is rejected, these ratios, and numberless others that might be cited in illustration of the law of multiple proportions, must be denied their only and obvious meaning.

The Law of Chemical Equivalents. The third law which can be explained by the atomic theory is known as the law of *chemical equivalents.* This, also, can be easily illustrated. Let us take a given quantity of hydrogen, say a gramme [for the meaning of this term, see PHYSICS]. Now, a gramme of hydrogen will unite exactly with eight grammes of oxygen, forming nine grammes of water and leaving over no oxygen and no hydrogen. Similarly, we find that if we take one gramme of hydrogen and 35·4 grammes of chlorine [refer to the table already printed, and note that this proportion is exactly the proportion of the atomic weights of hydrogen and chlorine], we find that the two will unite exactly, giving us 36·4 grammes of a compound called hydrochloric or muriatic acid, with the formula H Cl.

Illustrations of the Law. Now, the law of chemical equivalents states that chemical quantities which have equal power of forming chemical compounds are equal to one another. Thus, according to this law, eight grammes of oxygen are chemically equivalent to 35·4 grammes of chlorine, since each of these two quantities unites exactly with one gramme of hydrogen. But when we say that eight grammes of oxygen are chemically equivalent to 35·4 grammes of chlorine, we are saying in other words, on the atomic theory, that (if we double the two quantities, the relation is seen at once) two atoms of chlorine are chemically equivalent to one atom of oxygen, since two atoms of chlorine will weigh 70·8 and one atom of oxygen weighs 16. The ratio 70·8 to 16 is the same as the ratio of 35·4 to 8. Now, it is found that two atoms of chlorine are indeed equivalent to one atom of oxygen, for two atoms of chlorine will unite with two atoms of hydrogen (forming two molecules of H Cl), and one atom of oxygen will also unite with two atoms of hydrogen (forming one molecule of water, H_2O).

We may take the atomic weights of any elements at random and use them as our guides in indicating the proportions of the elements that may be expected exactly to combine with each other in the formation of compounds; and we find that the table of atomic weights is always a guide in such cases. Further confirmation of the atomic theory will be found in the subsequent chapter on the laws of chemistry.

Molecular Weight. Let us now return to the consideration of molecular weights—that is to say, the weights of molecules—which must necessarily depend upon the weights of the different atoms which compose them. The subject of molecular weights is exceedingly important, for we have already seen that elementary substances composed of only one kind of atom may appear in very different forms, having very different

properties, according to the number of the atoms that go to form each molecule. We saw this in the case of oxygen, O_2, and ozone, O_3. The importance of the subject of molecular weights is not fully realised in many text-books.

Quantitative Symbolism. Many writers use H and O as symbols of hydrogen and oxygen; but this will not do. H and O are simply short ways of writing the names of Hydrogen and Oxygen. The symbol for the substance we call oxygen is not O, but O_2. If we do not recognise this distinction, we are left with only one symbol, O, to describe the two very different substances, oxygen and ozone. Similarly, in the writing of equations, we must never shirk the extra trouble involved in using our formulæ properly. For instance, the easiest way of writing an equation to represent the decomposition of peroxide of hydrogen, H_2O_2, would be

$$H_2O_2 = H_2O + O.$$

But this is a very unsatisfactory way of writing the equation, unless we use it to express the fact already noted that for a moment the oxygen atoms are in a state of dissociation from each other, so that the oxygen is nascent, as chemists say. The actual result of decomposition of peroxide of hydrogen is the production of water and of ordinary oxygen—oxygen in which the oxygen atoms go about in pairs, and the formula of which is therefore O_2. Now, in order to express this properly, we must go to the trouble of doubling all the terms of the equation, and we must write it thus:

$$2\ H_2O_2 = 2\ H_2O + O_2$$

Similarly, the reader will find an illustration of the proper way of writing chemical equations if he turns back to the equation—the first we employed—that illustrates the decomposition of ozone into oxygen. It would not do at all to have written $O_3 = 3\ O$, because O stands for nothing. It is simply a short way of writing the name Oxygen; but the element oxygen is composed of two-atomed molecules, and, therefore, we have to write our equation as we did write it in order to show that the product of the decomposition consists of a certain number of two-atomed molecules, which we represent by the formulæ O_2. Having corrected this common error, and having undertaken never to sanction it, we may now pass to the consideration of molecular weights.

Actual Size of Molecules. The molecular weights to which we have hitherto referred are, of course, purely relative, like the atomic weights; but we may first ask ourselves whether anything is known as to the absolute size and weight of molecules. This subject belongs rather, perhaps, to the domain of physics than to the domain of chemistry; but, nevertheless, the chemical student must be interested to learn whether anything is known as to the actual size of these molecules to which he has to devote so much attention. A great deal of labour has been expended on this subject. Hitherto we have referred only to molecules containing a very few atoms, but there is an immense number of kinds of molecules that are relatively large and heavy, and contain hundreds of atoms. It is believed that the largest and most complex molecule known is that of hæmoglobin, which is the red colouring matter of the blood. This molecule is supposed to contain more than a thousand atoms belonging to the elements carbon, oxygen, hydrogen, nitrogen, iron, and possibly phosphorus.

The actual or absolute size of this enormous molecule has not been studied; but Lord Kelvin's calculations lead us to conclude that if a drop of water were magnified to the size of the earth, its molecules would be of a size ranging somewhere between that of small shot and that of cricket balls.

So much for the absolute size and weight of molecules. We must now consider a subject of much more importance to the chemist—which is their relative weight, and which he always means when he speaks of molecular weight.

Weight of a Volume of Gas. Avogadro's law, afterwards to be discussed, states that equal volumes of all gases at the same temperature and pressure contain the same number of molecules. This may be otherwise expressed by saying that the molecules of all gases occupy precisely the same space, given that they are placed under the same temperature and pressure. From our discovery of this law we are enabled to devise a method of ascertaining the molecular weight of a substance. We take the substance in the form of a gas or vapour (if the substance is not naturally a gas, we vaporise it or make into a gas for our purpose).

Assuming the truth of Avogadro's law, we see that a given volume of any gas, under given conditions of temperature and pressure, must differ from a similar volume of hydrogen under similar conditions precisely in so far as its molecules are heavier than those of hydrogen, for the law states that we are dealing with the same number of molecules in each case. If, then, the volume of the gas possesses a weight twice as heavy as the weight of a similar volume of hydrogen, the necessary inference is that each molecule of this gas weighs twice as much as a molecule of hydrogen.

Thus we can ascertain the molecular weight of any substance that can be studied in the form of a vapour or gas; but, unfortunately, a great many substances cannot be vaporised, and in their case other methods must be employed. These will not be dealt with at length here. The most important of them depends on the fact that, when a given quantity of any substance is dissolved in a liquid which simply dissolves it and does not affect it chemically, it lowers the freezing point of the liquid in exact proportion to its own molecular weight, which can thus be determined. A similar principle can be applied in various other ways, and by means of these freezing-point and boiling-point methods a great deal of information has recently been acquired concerning the molecular weights of a large number of elements, especially the metals and their nearest allies.

C. W. SALEEBY

The Growth of Rome in Power and Wealth and Her Decline in Public Virtue

THE RISE OF THE CÆSARS

THE circumstances of the expansion combined to lower the high moral standard of the Roman government which had prevailed down to the end of the Punic war. It was not only that the best of Rome's sons had fallen in battle in the prime of manhood, and that Italy was exhausted both in blood and treasure ; her vitality had only been debased without being destroyed. But the expansion introduced new temptations. An experiment without precedent had to be made in governing foreign dependencies. Consuls and prætors—the magistrates who stood next to them in rank—had their term of office extended on expiry, but their functions were exercised not in Rome but as governors of the provinces. The proprætor or pro-consul—these were the titles which they now bore—was, to all intents and purposes, an absolute ruler during the term of his office. The troops were under his command. He and his officials had almost unlimited opportunities for seeking their own advantage at the expense of the provincials ; and for many of them the temptation proved too strong.

The armies in the East learned new luxurious habits. The provincials themselves were not treated like the allies in Italy ; they were not called upon to supply contingents for Roman armies, but they were taxed the more heavily in proportion. The Roman troops which had to be maintained abroad could not long retain their character of a citizen army called to take the field only in time of war ; a professional army had become a necessity.

The best of the properly Roman population also had been drawn away from the city for a long time past to form military colonies, first in Italy and then in the provinces ; so that the population of Rome itself had degenerated, and yet for all practical purposes it was that population alone which had any active voice in political affairs. The old grievance of the absorption of the public lands into a small number of great estates worked by slave labour was more rampant than ever, while perhaps the worst feature of the situation was the moral deterioration of the governing class whose grand public spirit had saved Rome in the great Carthaginian crisis. And the Italians who had stood so loyally by the State in that crisis were now bitterly resenting the refusal of Rome to admit them to equal political rights, while the Roman populace was, for its part, fiercely jealous of any movement in that direction.

Expansion needed a reconstruction ; Rome under its old constitution could not control a world empire. It was not yet evident, though it was soon to become so, that the solution would have to be found in the concentration of power in the hands of one individual who should be not a tyrant ruling for his own advantage, but an incarnation of the State, and that the condition of such power was that the armies of the State should be under his direct control and leadership.

The inevitable revolution was started by Tiberius Gracchus, a member of a senatorial family, whose motives were those of a philanthropist rather than a statesman. Elected to the tribuneship, he set himself to remedy the agricultural grievance by re-enacting the laws against the absorption of public lands, and restoring those lands to their legitimate use. The wealthy classes found their prescriptive rights seriously endangered. Gracchus met their attack by unconstitutional procedure ; they took the law into their own hands, and he was killed in a riot. His younger brother, Gaius, ten years afterwards took up the task more as a statesman than a philanthropist. He had realised the necessity for recognising the claims of the Italians ; but he allowed himself to appeal to the populace by such methods as promising them a supply of corn at a fixed rate below the market value. He met with the same fate as his brother. The State became divided between the demagogic and the senatorial or oligarchical factions.

A war in Africa gave the popular party the upper hand through the military successes of the humbly born general Marius, although those achievements were largely due to his extremely aristocratic lieutenant, Sulla. Meanwhile, a new

enemy was threatening the Roman world. German tribes, the Cimbri and the Teutones, appeared on the scene for the first time, bursting into the province of Transalpine Gaul, where they overwhelmed the Roman armies. Marius was despatched against them, and put them utterly to rout in two great battles. For a time the deluge, which five hundred years later was to overwhelm the empire, was stayed. The victories of Marius, however, enabled him to reorganise the military system on lines which virtually set up a permanent standing army of professional soldiers; and an era opened in which political ascendancy became the prize of the trusted general whose legions would follow him to battle even in open rebellion against the civil authorities.

The Story of Sulla. Marius was no politician, but he became the tool of the popular party. In the meanwhile, a storm was developing in the East. The kingdom of Pontus, on the Black Sea, had been developing mightily under its king Mithradates, who flung down the challenge to the Roman Republic. There was a sharp contest between the two parties in Rome for the appointment of the commander in the East; the victory fell, after much bloodshed, to Sulla, the aristocrat, who departed with his legions, leaving the demagogues dominant in Rome. They used their power to proscribe and put to death large numbers of the senatorial party. There was a revolutionary reign of terror—until Sulla, having triumphantly beaten down Mithradates, returned with his legions to Italy, overthrew the demagogues after hard fighting, and crushed them by instituting a reign of terror on his own account. Then he set about reorganising the constitution on lines placing the whole power in the hands of the oligarchical party. At the height of his power, when he might have made himself permanently tyrant, he chose to resign, and shortly afterwards died, the victim of his own excesses.

The Rise of Pompey. Sulla instituted many reforms, but his constitution had in it no permanence. The state of affairs in Rome had called for his return when he had only scotched the danger in the East, not destroyed it. His successor there, Lucullus, was an exceedingly able soldier but extremely unpopular. In Spain the command remained in the hands of Sertorius, who was of the popular party. On the death of Sulla the two most powerful men in Rome itself were the extremely wealthy Crassus and young Pompeius, "Pompey the Great," who had distinguished himself as the lieutenant of Sulla in the fight against Marius.

Pompey was despatched to Spain to deal with Sertorius. Crassus was in Rome, playing for his own hand by financial methods. The brilliant orator Cicero, in his own estimation at least, was the leader of the senatorial party, the "Optimates," though his amiable ideals were very far from coinciding with most of theirs, little as he appreciated the fact. A young aristocrat, Julius Cæsar, was pushing his way to the leadership of the popular party.

CICERO DENOUNCING THE CONSPIRATOR CATILINE IN THE SENATE HOUSE AT ROME

A Powerful Trio. Such was the position when Pompey returned after the subjugation of Spain. But Pompey did not find the senatorial party ready with so full an acknowledgment of his services as he expected. Cæsar offered his alliance, and brought Crassus into the combination. The command in the East was bestowed upon Pompey, with virtually unlimited powers. Pompey, having destroyed the swarms of pirates who dominated the whole eastern Mediterranean, proceeded to the subjugation of Asia as far as the Euphrates.

Meanwhile the extremists of the popular party plotted a revolution, headed by the notorious Catiline. The conspiracy was discovered and crushed, not without the employment of unconstitutional methods, more or less justified in the emergency, by Cicero. There were not

CÆSAR LANDS IN ENGLAND & FALLS IN ROME

THE FIRST LANDING OF JULIUS CÆSAR ON THE SHORES OF GREAT BRITAIN, IN THE YEAR 55 B.C.

THE ASSASSINATION OF JULIUS CÆSAR IN THE ROMAN SENATE HOUSE

wanting enemies who declared that both Cæsar and Crassus were implicated, and efforts were made to have Cæsar proscribed.

Pompey, on his return with his legions and his laurels, might easily have made himself master of the State; but when it came to defying the constitution he always drew back, although he always hankered to exercise a supreme power. In accordance with the law, he disbanded his forces on landing.

Cæsar's Success. Cæsar, on the other hand, had grasped the fact that the military supremacy of one man was a necessity. He meant himself to be the one man, but he could able to claim that he had added the island to the fast-increasing possessions of Rome.

Crossing the Rubicon. Cæsar's successes alarmed Pompey. As pro-consul, his command over the military forces in Gaul, both Cisalpine and Transalpine, was absolute, but if he led his troops outside his own province he would be committing an act of rebellion against the Republic. Cæsar saw that if he came to Rome without the legions at his back his fall was certain. The boundary of his province was the river Rubicon, in the north of Italy. He resolved upon the great adventure, and "crossed the Rubicon" with his well-disciplined troops.

MARK ANTONY HARANGUING THE ROMAN PEOPLE AFTER THE MURDER OF CÆSAR

only get the military supremacy by becoming the master of legions; and he could only become a master of legions as a provincial governor. As Pompey's ally, he procured for himself the pro-consulship of Gaul for five years, afterwards extended to ten. Crassus was killed on an expedition against the Parthians. During those ten years Cæsar proved his generalship by the subjugation of the whole of Gaul, which he brought under the Roman dominion. Incidentally he paid two visits to the island of Britain, where he made no attempt at a permanent conquest, though by extracting something in the nature of a tribute from sundry chiefs he was

He was now in open rebellion. But in Italy itself there were no legions; the armies were in the provinces; Pompey withdrew to Greece to gather a force which should crush the enemy of the Republic. Cæsar made himself master of Rome and of the treasury. Before engaging in the decisive struggle with Pompey, he flung himself upon Spain in order to crush in the bud any possibilities of a serious resistance to him arising from that quarter. Then he turned upon Pompey, whose great army he routed utterly at the battle of Pharsalia.

Cæsar Master of the World. Pompey, retreating to the East to raise fresh armies, with

Cæsar in hot pursuit, made his way to Egypt, but was assassinated as he was landing. Cæsar had now to crush the Asiatics who were in arms under Pharnaces, a son of Mithradates; and thence he returned to Italy, where his combined vigour and leniency restored order. It was still necessary for him to crush, at the battle of Thapsus, the Pompeians who had rallied in Africa. He came back to Italy, but Spain rose in revolt under Pompey's son, Sextus. Again he had to take the field, and to crush the revolt at the battle of Munda.

Cæsar had crossed the Rubicon in 49 B.C. Munda was fought four years later, in 45 B.C. to recognise the greatness of the man. Although he publicly refused the crown, the dominion of one man was traditionally abhorrent to Romans. Self-seeking politicians and fanatical republicans, who dreamed an impossible dream of the restoration of an aristocratic republic, combined in a plot against the great man's life. In spite of warnings his magnanimity scorned to take precautions for his own defence, and on the Ides—that is, the 15th—of March, 44 B.C., Cæsar fell beneath the daggers of his assassins, among whom the most notable were Cassius, Decimus Brutus (the ablest soldier among them), and Marcus Brutus, Cæsar's familiar friend. Each

VIRGIL, HORACE, AND VARRO, WITH MÆCENAS, THE PATRON OF ROMAN LITERATURE

In the intervals of fighting during those four years, Cæsar had procured at Rome his own appointment as dictator for ten years; he had introduced various reforms, including incidentally that of the calendar, establishing almost with accuracy the exact solar year of 365 days, with an extra day in every fourth year. He had re-organised the system of provincial government, and had made himself the authority in the appointment to all military commands. He was now planning a war in the Far East against the expanding power of the Parthians beyond the Euphrates. He was in effect absolute master of the whole Roman world.

The Penalty of Leniency. But he was to pay the penalty for the leniency shown to political opponents, who were not magnanimous enough

of these three leaders had been nominated to a provincial governorship.

Dreams that Failed. When Cæsar fell, the conspirators dreamed of a republic, of a government by a narrow oligarchical faction. The great orator Cicero dreamed of a broad combination between the aristocrats and the cultured middle-class. Neither dream was possible of realisation. Mark Antony, one of Cæsar's trusted lieutenants, the boy Octavius, great-nephew and heir of Julius, and another of Cæsar's lieutenants, Lepidus, all had their own ambitions. They united in a triumvirate, to establish their own rule, and to avenge the murdered dictator. The legions who had served and loved Cæsar were ready to follow them against the aristocratic party.

Marcus Brutus and Cassius departed to their pro-consulates in the East to raise forces. Decimus Brutus went to North Italy, but was killed. Octavius, Antony, and Lepidus, who now dominated Italy, having agreed upon an arrangement by which they were to be appointed commissioners for the reorganisation of the State, the Senate could see no way out of the difficulty other than by sanctioning and ratifying this new and startling triumvirate.

Great Men's Deaths. The usual effects of sudden changes in the rule of a State ensued—a proscription against all who had opposed the newly self-constituted authorities. The name of Cicero, who had been specially hostile to Antony, held an early place on the list of the proscribed. Cicero was then in his sixty-third year—the time was within some forty-three years of our Christian Era. Overtaken by Antony's troops as he fled from Rome, he was executed on the spot.

When the triumvirs were sated with vengeance on their political adversaries and personal enemies, Octavius and Antony passed into Greece on their way to meet the rival army of Brutus and Cassius, and completely defeated it at Philippi, 42 B.C. Cassius and Brutus, seeing all was lost, determined to die; Cassius compelled his freedman to kill him, and Brutus killed himself with his own sword.

The Fall of Antony. Octavius now settled down to consolidate his power in Italy. Antony went off to secure the East, and there met with Cleopatra, by whom he became enslaved. But for that frantic enchantment, Antony might have crushed Octavius and made himself master of the world. But when the inevitable struggle between the rivals took place, at the great sea-fight of Actium, Cleopatra had her galleys withdrawn from the front, and Antony followed her in her flight. The Egyptian fleet was wholly defeated, and when his cause seemed lost Antony committed suicide.

Cleopatra tried the effect of her charms on Octavius, but found him made of much less impressionable stuff than Antony; and, seeing no hope of gratifying her ambition, she put herself to death.

The First Augustus. Lepidus had long ceased to count, and Octavius stood alone at the head of the Roman world. He knew that the salvation of Rome could only be effected through an absolute monarchy veiled under republican forms. On his return to Rome he resigned the exceptional powers which had been entrusted to him. The Senate, however, at once decreed to him a new tenure of the dictatorship for ten years, with the understanding that the term of office should be renewed as often as might be deemed necessary in the interests of the country. Octavius accepted these conditions, and received from the Senate the title of Augustus.

Princeps and Imperator. He was now Augustus Cæsar, with precedence over all men in official position. He was also commander-in-chief of the army, and it was decreed that to him alone could belong the right of making treaties, of declaring war, and of offering or accepting terms of peace. He was emperor in everything but the name. These powers were conveyed to him without destroying constitutional forms, by extending to him, first for a term of years, and then for life, the tribunician powers in Rome and the pro-consular powers in all the further provinces, as pro-consular powers had been extended to Pompey and Julius Cæsar. Also, he was officially recognised not as king, but as "Princeps"—the "first citizen." Even the title of Imperator, our Emperor, attached to him as the official head of the armies.

In effect the Princeps was endowed with permanent pro-consular authority in all the frontier provinces of the empire, wherein all the troops, except the select bodyguard, were stationed. All the higher officers were appointed by and responsible to him personally as his legates; consequently he held complete control of the whole effective military force of the empire. The "home" provinces remained in theory under the control of the Senate.

An Imperial Reformer. Augustus was, above all things, a practical reformer. He established a census, alike of individuals and of property. He introduced a new principle of finance and taxation; he based his taxing system mainly on the land and the personal possessions of the citizens, and he abolished a large number of unequal and capricious imposts which bore heavily on the poor. The financial accounts of the State were kept with strict accuracy, and he introduced the practice of framing what would now be called an annual State Budget. He appointed the governors of all the State provinces, and he personally arranged that the taxation of each province was fairly imposed, and properly accounted for. He took an interest in the affairs of the different municipalities, and he established a police force to keep good order in the towns. He developed, as far as possible, that system of municipal government which began in the Roman states under the guidance of Julius Cæsar.

The Age of Roman Culture. Augustus was a lover of literature. He was the patron of poets, historians, and scholars, of painters and of sculptors. In his reign Virgil expressed the great Roman ideals in the noble epic the "Æneid"; Horace is famous as the author of lyrical and satirical poems unsurpassed in any literature; Ovid, Tibullus, Propertius were notable poets; Livy is one of the most picturesque, fascinating, and philosophical historians of any era. The literary glories of the reign have caused the term "Augustan Age" to be applied to other eras when classicalism has flourished, such as the age of Louis XIV. in France and of Queen Anne in England. A whole society of wits and humorists, makers of verses, and writers of essays flourished under the influence and patronage of the Court, and Rome seemed like another Athens—Athens in its best days. Mæcenas, friend of Augustus and patron of art and literature, lived in this period.

Augustus wished to preserve the Rhine, the Danube, and the Euphrates as the frontiers of the empire. German tribes were pressing on the Rhine and Danube, and a great disaster befell the Imperial troops when they pushed over the Rhine. A Roman force led by a general named Varus was skilfully drawn into an ambush by the enemy and cut to pieces, Varus himself being among the first to meet with death.

Man's New Exalted Faith and Hope. Some years earlier an event had occurred in a distant province of Rome which brought on

OCTAVIUS CÆSAR AND CLEOPATRA AFTER THE OVERTHROW OF MARK ANTONY
From the painting by J. L. Gérôme, by permission of Messrs. Goupil & Co.

the world the greatest change it has ever known in its history. That event was the birth of Christ and the founding of the Christian religion. It is no part of our task to attempt in this course a detailed record of the events which are told in sacred volumes, are represented in the creed of Christianity, and have opened a new hope and faith for civilisation. Our purpose is to tell the story of the Roman Empire. The tragedy which was enacted in Jerusalem towards the end of the reign of the successor of Augustus was enacted, indeed, under the authority of the Imperial Government, but that Imperial Government and the Roman people took little interest in the rise of the Christian movement and in the steps taken by the authorities in Palestine to resist its influence.

A Reign of Peace and Success. Augustus died at the close of August in A.D. 14, at the age of seventy-six. He had ruled over Rome for more than forty years, and his reign was the happiest and the most prosperous that Rome had known or was to know for many generations. He had married three times, but left no son to succeed him. His first wife left him a daughter, Julia, who, after the death of her first husband, married Marcus Agrippa, who died in A.D. 12. Augustus adopted two of her sons by this marriage, the elder to be his successor to the throne. Both these sons died in their youth, and the obvious heir to the principate was Tiberius, the stepson of Augustus, to whom more than to any other man had been due the successful preservation of the Rhine and Danube frontiers.

History and Scope of Ordnance Survey Maps. Land Measurements in Great Britain and Abroad.

THE ORDNANCE SURVEY

History. The Ordnance survey is a trigonometrical survey of the United Kingdom, and is performed by officers and men of the Royal Engineers.

Apart from all scientific and other considerations, it must be admitted that this survey of the United Kingdom has, so far as the public is concerned, more than fulfilled the object it was intended to accomplish. It is, in fact, the only reliable survey of the country that is published and available for reference.

The preparation by the Government of a general map for any portion of the country was first proposed after the rebellion of 1745, when the want of a reliable map of the northern parts of Scotland was much felt by Army officers. This was the first State survey of any portion of the King's dominions that was ordered for military purposes. This extensive work was entrusted to Lieutenant-General Watson, the Deputy Quartermaster of Great Britain, who, with the aid of Major-General Roy, was engaged for 10 years in executing the work. The map was drawn to a scale of $1\frac{3}{4}$ in. to the mile, but it was never published. Twenty-nine years elapsed before any other portion of the country was surveyed by the State, and then the work was undertaken for scientific, rather than for military, purposes. It was with the object of calculating the difference of longitude between the observatories of London and Paris that, in 1784, General Roy measured a base-line on Hounslow Heath, which started a series of triangles extending to Dover.

Origin of the Present Ordnance Map. A few years later the Government decided upon having a general survey of the United Kingdom prepared for military purposes. This was the origin of the present 1-in. Ordnance map, and the triangulation carried out by General Roy in the south-eastern counties became the basis of the general triangulation. As the survey was extended westwards it was considered advisable to measure another base-line. This was done on Salisbury Plain, and for purposes of verification other lines were measured, at Misterton Carr, in 1801, and Rhuddlan Marsh, in Flintshire, in 1806. The first sheet of this survey was published in 1801. About this period the public utility of State charts for purposes other than those of a military character began to be recognised. The public demand for better maps than were then available became so great that surveyors were engaged for the purpose of pressing forward the completion of the 1 in. survey that was then in hand.

The principal triangulation in Scotland was undertaken in 1809. But little progress had been made when the officials and surveyors were withdrawn to enable them to carry forward the detail maps of England. Going north again in 1813, the work was pushed steadily forward for six or seven years. In the three following years the Scottish survey, although not altogether suspended, made but little headway.

The survey of Ireland was required for political and administrative purposes, and the Government decided that the map should be prepared to the scale of 6 in. to the mile, and the chief strength of the surveying corps was transferred to Ireland for this purpose. The map was completed in 1845.

The value of this 6-in. map having been proved, a survey for a similar map was commenced in the northern counties of England in 1840, and in the following year secondary operations for a map of Scotland, also on a larger scale, were begun, but in 1851 a committee of the House of Commons recommended that the 6-in. maps be stopped and the 1-in. maps completed in detail.

Triangulation of the United Kingdom. The primary triangulation of the United Kingdom was finally completed in 1852. It comprises in all 250 trigonometrical stations, and a map showing all these lines, which is very seldom seen, presents the appearance of a huge spider's web, with its centre laid on Salisbury Plain. The average length of the sides of the triangles is 35·4 miles, and the longest measures 111 miles. The accuracy, or otherwise, with which the triangulation was carried out was at one time tested, with extremely satisfactory results. The length of the base-line measured in Ireland on the border of Lough Foyle was calculated through a series of triangles from the base on Salisbury Plain, and the length so found differed from the calculated length by only four and a half inches. The distance apart of these two bases is about 360 miles, and their length about 41,614 ft. and 36,578 ft. respectively.

From the opinion of a large number of the most eminent scientific and practical men it was found that the great preponderance of opinion was in favour of a scale of $\frac{1}{2500}$th, or nearly 1 in. to the acre. This scale was therefore ordered in May, 1855.

The charge of the Ordnance survey was transferred to the Board of Agriculture on its formation in 1890.

Maps and their Uses. The standard maps published by the Ordnance Survey Department, and obtainable from Edward Stanford, of 12, 13, and 14, Long Acre, W.C.,

the sole London agent, and from the Ordnance Survey Office, Southampton, are those described in detail below.

General Map. (One inch to the statute mile.) This Survey of Great Britain and Ireland, reduced from the 6-inch maps, is well adapted for all ordinary purposes, such as walking or driving, and admirable residential maps can be made up for 10, 15, or 20 miles round any centre, suitable either for hanging in the hall, billiard-room, or study. The whole of England and Wales has been revised since 1893, a further revision (third edition) is approaching completion, and a fourth edition is begun.

The sheets can be had either in an engraved edition, in outline, with contours, or in a colour-printed edition showing water blue, hills brown, contours red, roads sienna, and county boundaries. Pedestrians will find this map very useful for tourist purposes, while the new map on the scale of two miles to an inch, and the coloured map on the scale of four miles to an inch, will prove of service for motoring and driving.

County and Other Maps. These maps are published on the 6-inch and 25-inch scale. Clergymen, schoolmasters, and landed gentlemen will find the maps invaluable as accurate delineations of their parishes or districts.

Town plans, 5 feet or 10½ feet to 1 mile, are published for certain towns. Municipal bodies, urban and rural district councils, parish councils, engineers, estate agents, and surveyors will find these large scale maps of great use for lighting, drainage, paving, rating, and general estate purposes. A new half-inch map is published on the scale of two miles to an inch, in 40 sheets, mostly 30 by 21 inches. It is printed in colours showing hills and contours in brown, water blue, woods green, outline black, and chief roads sienna. A quarter-inch map, on the scale of four miles to an inch, is published in 18 sheets, size 22½ inches by 16 inches, in two forms, one engraved in outline and the other a coloured edition showing water blue, hills brown, roads sienna, and woods green.

Library Map. A useful map is the revised edition of the library map, constructed on the basis of the Ordnance Survey and the Census, and adapted to the various branches of civil or religious administration; it shows railways and stations, main roads, canals, principal parks, antiquities, and other features of interest. The cities, boroughs, towns and villages are engraved in special characters according to their relative importance; antiquities, parks, and mansions, main roads, railways, canals, coastguard stations, lighthouses and light-vessels, lifeboat stations, county towns, municipal boroughs, number of parliamentary representatives, towns where assizes or quarter sessions are held, cathedrals, military headquarters, and ports of entry are all indicated by suitable symbols.

The whole forms the most comprehensive work of reference on England and Wales which has been presented to the public in the shape of a map. The scale is 7¾ miles to an inch, that is to say, 1 : 486,830.

School Map. Stanford's extra large map of England and Wales forms the grandest map of England and Wales for wall purposes ever published. The lettering is so bold and distinct that it can be read easily at a distance of ten or twelve feet, and at this distance the rivers and hill features can be clearly traced. All places having 2000 inhabitants and upwards will be found on the map. The scale is 3¾ miles to an inch (1 : 237,600).

Scales. The Natural Scale which is found on maps is the scale of comparison between the measurement on the map and the measurement on the ground represented by the map. For example, the natural scale 1 : 63,360, or as sometimes written $\frac{1}{63360}$, indicates that 1 inch (or 1 foot, or any other unit of measurement) on the map equals 63,360 inches (or feet, or whatever may be the unit of measurement) on the ground. As there are 63,360 inches in 1 statute mile, this scale is concisely stated as "1 inch to a mile," and written 1 : 63,360.

Engineers and surveyors find the Ordnance maps and area books absolutely necessary for much of their work. The Ordnance Survey reference books give the area of every field and enclosure to the thousandth of an acre, in acres and decimals.

Ordnance Datum. The bench marks of the Ordnance surveys are of this pattern and are known as Ordnance bench marks (O.B.M.).

The horizontal line represents the spirit level, and the three strokes forming the arrow represent the legs of the stand of the level (technically known as the tripod). On the sheets of the Ordnance Survey the levels of the several bench marks are numbered in feet and decimals of a foot above mean high-water mark at Liverpool, which is assumed to be 0·650 of a foot below the general mean level of the sea. These heights have been determined at many points throughout the country; each is designated by the mark referred to, being in a wall, or footpath, or milestone, at the spot indicated on the Ordnance map.

Land Measures. Originally land measure differed in various parts of England, and was governed by the custom of the particular locality in which the land was situated, hence the term "Customary Measure."

Now, however, land measure for the whole of England is governed by Statutes 34 Henry VIII., 5 George IV., chap. 74, and 5 and 6 William IV., chap. 63; hence the term "Statute Measure." Consequently, in old documents, we occasionally come across plans giving the area of lands in customary acres, roods, and perches, and it is, therefore, necessary to reduce *customary* to *statute*, and sometimes statute to customary measure.

The same remark applies also, in some cases, when dealing with land in Scotland or Ireland, or other parts of the world, where the land measure differs from our statute measure.

1. By the Act 5 George IV., chap. 74 (June 17th, 1824), it is enacted: "That our

present yard shall be denominated the 'Imperial standard yard'; and shall be the unit, or only standard measure of extension, whereby all other measures of extension whatsoever, whether the same be lineal, superficial, or solid, shall be derived and computed; and that all measures of length shall be taken in parts, or multiples, or certain proportions, of the said standard yard; and that one-third part of the said standard yard shall be a foot, and the twelfth part of such foot shall be an inch; and that the rod, pole, or perch in length, shall contain five such yards and a half; the furlong, two hundred and twenty such yards; and the mile one thousand seven hundred and sixty such yards."

2. By the same statute it is enacted that all superficial measures shall be computed by the said standard yard, or by certain parts, multiples, or proportions thereof; and that the rood of land shall contain one thousand two hundred and ten square yards; and that the acre of land shall contain four thousand eight hundred and forty such square yards, being one hundred and sixty square rods, poles, or perches.

3. By the Act 5 and 6 William IV., chap. 63 (September 9th, 1835), all *local* or *customary* weights and measures are abolished, not only in England and Wales, but also in Scotland and Ireland.

Multiples of the Yard. The yard being the British standard length, it is multiplied into chains, furlongs, and miles, and divided into feet and inches, the chain of 22 yards being divided into 100 parts, or links, each of which measures 7·92 inches.

In the school table-books $5\frac{1}{2}$ yards is called 1 rod, pole, or perch, and the square formed by this length, containing $30\frac{1}{4}$ sq. yd., is called 1 sq. rod, pole, or perch.

Surveyors object to this confusion of terms, and are generally agreed that the term pole shall be used for lineal measure, and perch for square measure, so that areas in land surveying are usually stated in acres, roods and perches, any fraction over being stated as $\frac{1}{4}$, $\frac{1}{2}$, or $\frac{3}{4}$, to whichever of these it is nearest.

The Ordnance surveyors use three places of decimals for the fractional perches, giving an appearance of accuracy which the work itself will not warrant, as an allowable error is 1 perch per acre.

Formerly, by custom, the perch varied in different parts of England, and with it, consequently, the acre also varied in proportion. In Devonshire and part of Somersetshire, 15 ft., in Cornwall, 18 ft., in Lancashire, 21 ft., and in Cheshire and Staffordshire, 24 ft. were accounted a perch. In the common field-lands of Wiltshire there was a customary measure of a different nature—*viz.*, of 120 instead of 160 statute perches to an acre, so that 30 perches of statute measure made 1 rood of customary, or 3 statute roods made 1 customary acre, or 30 statute perches made 1 rood, and 4 such roods made 1 acre customary measure.

It may be observed that 4,840 sq. yd. make 1 statute acre—3,630 made 1 Wiltshire acre, 4,000 made 1 Devonshire or Somersetshire acre, 5,760 made 1 Cornwall acre, 7,840 made 1 Lancashire acre, and 10,240 sq. yd. made 1 acre of the customary measure of Cheshire or Staffordshire.

The Scotch acre contained $1,244\frac{1}{9}$ sq. yd., and the Irish acre 3,000 sq. yd. more than the English statute acre; while the Scotch mile was $216\frac{1}{2}$ and the Irish mile 480 yards more than the English mile.

The standards of measurement in London for testing chains, rules, and rods are situated in the Guildhall and on the north side of Trafalgar Square, and may be used free of charge.

Reducing to Statute Measure. In many old surveys and plans the area is given in local and customary acres, rods, and perches, consequently it is necessary to give the method of reducing local or customary measures of land to statute measure and statute to customary measure.

METHOD No. 1. When the number of feet in a customary perch is given, reduce the customary quantity to square feet, and divide by 272·25, the number of square feet in a statute perch, and again divide the quotient by 160, the square perches in an acre for acres; and the remainder, multiplied successively by 4 and 40, and divided successively by 160, will give the roods and perches statute measure.

METHOD No. 2. When the number of square yards in a customary acre is given, reduce the area (customary measure) to acres and decimals of an acre, multiply by the number of square yards in a customary acre, and divide by 4840, the square yards in a statute acre, and reduce the decimals to roods and perches by multiplying successively by 4 and 40.

Old Maps. When boundaries are in dispute, it is necessary to refer to all available records, such as old parish maps in the possession of the clerk or surveyor to the district council, maps attached to or accompanying leases and conveyances in the hands of the owners or occupiers of the property, or their solicitors or agents; maps in the custody of the lord of the manor or his agent; occasionally maps in the Record Office and elsewhere. Sometimes the precise boundary cannot be ascertained, but a careful inspection of the ground throughout the supposed course of the boundary will often show, by a bush here and there, and slight elevations or depressions of the surface, the probable course of a former hedge and ditch. Against a public road the boundary hedge may have been kept in fair order, but the ditch allowed to become gradually filled up and effaced, in which case the authorities may claim up to the centre of the hedge as public property, and, although they may not be entitled to it, their claim is difficult to disprove.

A. TAYLOR ALLEN

Milton, Dryden, Pope, Thomson, Gray, Cowper, Burns, and the Minor Poets of the Period.

POETRY FROM MILTON TO COWPER

THE period we are now about to consider is one in which the lessons urged by the critical school of Ben Jonson bore fruit. The greatest name among the poets of the age that witnessed the rise of the Commonwealth and the downfall of the Stuarts is that of the author of "Paradise Lost."

JOHN MILTON (b. 1609; d. 1674), "God-gifted organ voice of England," was the son of a scrivener who had been disinherited by his father for changing his faith to that of the Reformers. His early years are thus described in his own words:

> When I was yet a child no childish play
> To me was pleasing; all my mind was set
> Serious to learn and know, and thence to do
> What might be public good; myself I thought
> Born to that end, born to promote all truth,
> All righteous things.

Though he wrote verses at the age of ten, and paraphrases of the Psalms (including the well-known "Let us with a gladsome mind") as a schoolboy, we find him in the sonnet "On Arriving at the Age of Twenty-three" lamenting his "late spring."

His early poems were inspired by the pastoral surroundings of Horton, in Buckinghamshire, where, after leaving Cambridge, Milton spent five years under the parental roof. "L'Allegro" and "Il Penseroso" are mirthful and pensive poems respectively, as their titles imply. Each has supplied the world with many oft-quoted phrases and lines. "Comus" is a masque, beneath the exquisite allegory of which may be discerned the poet's political bent, and the whole is rich with promise of the work by which its author is most widely known. "Lycidas" is an elegiac poem composed in memory of a college friend. It breathes such a contempt for the corrupt holders of ecclesiastical benefices as to make one wonder why it was not made the subject of a Star Chamber "inquiry." Having pondered these poems, the student should read the beautiful lines, "At a solemn music." The works mentioned were composed between the years 1631 and 1637, when, to quote the glowing words of Mr. Edmund Gosse, Milton "contributed to English literature about two thousand of the most exquisite, the most perfect, the most consummately executed verses which are to be discovered in the language. This apparition of Milton at Horton," Mr. Gosse goes on to remark, "without associates, without external stimulus, Virtue seeing 'to do what Virtue would by his own radiant light,' this is one of the most extraordinary phenomena which we encounter in our [literary] history."

Milton's "Paradise Lost" is the best known of all his writings. Though owing something, doubtless, to Spenser's "Faëry Queen," it is not only the first English epic; it is unapproached save by Tennyson's "Idylls of the King." There are various forms of this particular class of poetry; its foreign masters are Homer, Virgil, Tasso, Ariosto, and Dante. Milton's original conception was of a drama on the Arthurian legends. Perhaps the Civil War which intervened between the conception and the performance of the work supplied sufficient motive for a theme of a more sublime and solemn character than even those associated with the Round Table. But, as Milton's great editor, Professor Masson, reminds us, Milton inherited, as it were, a subject with which the imagination of Christendom has long been fascinated. "Paradise Lost" is more than the outpourings of a richly stored mind saturated in the classics and the Bible. It is an epic that has no parallel in our own or in any other language. "It is an epic of the whole human species—an epic of our entire planet, or, indeed, of the entire astronomical universe. The title of the poem, though perhaps the best that could have been chosen, hardly indicates beforehand the full nature or extent of the theme; nor are the opening lines, by themselves, sufficiently descriptive of what is to follow. It is the vast comprehension of the story, both in space and time, that makes it unique among epics, and entitled Milton to speak of it as involving

> Things unattempted yet in prose or rnyme.

It is, in short, a poetical representation, on

the authority of hints from the Book of Genesis, of the historical connection between human time and aboriginal or eternal infinity, or between our created world and the immeasurable and inconceivable universe of pre-human existence."

Milton's "Ode on the Morning of the Nativity," written in his Cambridge days, conveyed the theory that the pagan gods were fallen angels. "Paradise Lost" deals with the Rebellion in heaven, the Creation, the Temptation, and the Fall. But that Satan is the hero we beg to disbelieve, despite even Professor Masson's dictum. Milton was too full of humanity—witness his twenty years of patriotic service—to idealise the Evil One. It is man himself he sings. Certainly, the deepest interest attaching to both "Paradise Lost" and "Paradise Regained" is inspired by the study of the character of Satan as the tempter of man and the tempter of Christ. But this interest arises from the *object*, or *subject*, of each encounter. The lesson derivable is twofold. On the one hand, we are brought to a consideration of the misuse of a Divinely given freedom: on the other is enforced the conclusion that God is "Grace Abounding." Of "Paradise Lost" Coleridge said that "no man can rise from the perusal of this immortal poem without a deep sense of the grandeur and purity of Milton's soul."

Samson Agonistes. This was Milton's last work, and is a drama on the Greek model, founded on the Book of Judges, but, as the author expressly states, not designed for the stage. It is the work of one whose cause had been nobly fought for, and hardly lost. The thoughts uttered by Samson came from the heart of the poet who wrote them. The work is severe in style, but derives its highest value from the parallels it offers between the lives of Samson and Milton himself. For our present purpose what we wish especially to emphasise is the importance of the study of Milton's work to all who aspire to the proper and most effective use of their mother tongue. To Milton may be ascribed Spenser's eulogy of Chaucer as "a well of English undefyled." He had, like Achilles, one defect: he had no sense of humour.

S me of Milton's Contemporaries. THOMAS RANDOLPH (b. 1605; d. 1634) need not detain any but the advanced student. EDMUND WALLER (b. 1605; d. 1687) lives as the author of "Go, lovely Rose" and "Lines on a Girdle," lyrics which "might almost be chosen from English literature to serve as examples of the charms of simplicity and directness." SIR JOHN SUCKLING (b. 1609; d. 1642) is saved from oblivion by a song, "Why so pale and wan, fond lover?" and a ballad upon a wedding, beginning, "Her feet beneath her petticoat." SIR RICHARD LOVELACE (b. 1618; d. 1658) is the author of a poem, "To Althea, from Prison," the first two lines of the last stanza of which are common property:

> Stone walls do not a prison make,
> Nor iron bars a cage.

RICHARD CRASHAW (b. 1613; d. 1649), a transcendentalist, and author of "The Flaming Heart," is responsible for the familiar phrase "That not impossible she." SIR JOHN DENHAM (b. 1615; d. 1669) is the author of a contemplative poem, "Cooper's Hill," which supplies an early model of the rhythmical couplet. ABRAHAM COWLEY (b. 1618; d. 1667) was another of Dryden's predecessors. Today Cowley is chiefly read for his prose, though, in his own lifetime, he was one of the most popular poets of the day. He belonged to what Johnson called the "metaphysical" school of Donne, of which we have already heard in our Elizabethan studies. Cowley's "Pindaric Odes" prompted the "Alexander's Feast" of Dryden. SAMUEL BUTLER (b. 1612; d. 1680), in his inimitable satiric poem "Hudibras," which was written in ridicule of the Puritans, displays much learning as well as wit. ANDREW MARVELL (b. 1621; d. 1678) was a friend of Milton, played the part of laureate during the Protector's life, and wrote a "Horatian Ode upon Cromwell's Return from Ireland," which Trench specially commends to English students of Horace. Marvell's lines on the "Emigrants in the Bermudas" are even better known than the Horatian ode. HENRY VAUGHAN (b. 1621; d. 1693) was a follower of George Herbert, with a mystical note of his own.

John Dryden. We now come to a name second only in importance to that of Milton in the period under review. JOHN DRYDEN (b. 1631; d. 1700) is England's greatest satirist in verse. His influence upon his contemporaries was tremendous. His critical deliverances are reverenced today. He excelled as a dramatist and as a writer of prose. For the moment, however, we have to concern ourselves with his poems. One of the first of his characteristics that strikes us is his alertness to the significance of events in the world outside the library. Witness his "Annus Mirabilis" (the "Wonderful Year" of 1666), wherein he celebrates the English victories over the Dutch at sea and the benefits of the Great Fire of London.

In "Absalom and Achitophel" Dryden directed the whole weight of his powerful intellect to the undoing of the Earl of Shaftesbury's scheme for inducing Charles II. to nominate his illegitimate son, the Duke of Monmouth, as his successor to the Throne against the lawful claim of the King's brother James, who was a Romanist. At this time, it should be remembered, Dryden, though soon to adopt the Romish faith (see "The Hind and the Panther"), was strongly Protestant, as may be proved by reference to the work that followed "Absalom and Achitophel"—"Religio Laici." Taking as his model the story of Absalom's revolt against David, Dryden named the various parties to the Monmouth plot after the characters in 2 Samuel. The portrait of Shaftesbury, beginning

> Of those the false Achitophel was first—
> A name to all succeeding ages curst;
> In friendship false, implacable in hate,
> Resolved to ruin or to rule the State,

is the most telling example of passionately concentrated poetic portraiture in our literature.

Dryden's Poetic Power. Three other works by Dryden exhibit his splendid lyrical ability—the "Ode to the Memory of Mrs. Anne Killigrew," described by Johnson as "the noblest in our language," the "Song for St. Cecilia's Day," and "Alexander's Feast." Dryden's translations are subjects for advanced study. One of his chief claims to our attention is that directness and masculine vigour of his language which almost any half-dozen lines of his verse would illustrate. "Amid the rickety sentiment looming big through misty phrase which marks so much of modern literature," writes James Russell Lowell, "to read Dryden is as bracing as a north-west wind. He blows the mind clear. In ripeness of mind and bluff heartiness of expression he takes rank with the best. His phrase is always a short cut to his sense. He had beyond most the gift of the right word; and if he does not, like one or two of the Greek masters of song, stir our sympathies by that indefinable aroma, so magical in arousing the subtle associations of the soul, he has this in common with the few great writers that the winged seeds of his thought imbed themselves in the memory, and germinate there."

The Principal Poets between Dryden and Pope. MATTHEW PRIOR (b. 1664; d. 1721) wrote a clever parody of Dryden's "The Hind and the Panther," called "The Country and the City Mouse." His muse, as Hazlitt says, was "a wanton flirt." His poems and lyrics are marked by an easy air of abandonment, but have at least the merit of originality as well as wit. JOSEPH ADDISON (b. 1672; d. 1719) wrote poems and a tragedy, "Cato," which Voltaire greatly admired, but it is by his views on poets—his work, for example, in popularising Milton—and his essays that he is best known.

NICHOLAS ROWE (b. 1674; d. 1718) translated Lucan's "Pharsalia," and wrote the still effective drama of "Jane Shore," but is best remembered as a biographer and editor of Shakespeare. THOMAS PARNELL (b. 1679; d. 1718), author of "The Hermit" and "The Fairy Tale," aided Pope in his translation of the "Iliad," and wrote an "Elegy to an Old Beauty," of which one line is often quoted:

> We call it only pretty Fanny's way.

EDWARD YOUNG (b. 1683; d. 1765) was a far from admirable character. His "Night Thoughts" have all the gloom but little of the grandeur of "otherworldliness." JOHN GAY (b. 1685; d. 1732) was the author of several delightful songs. "'Twas when the seas were roaring," "Molly Mog," and "Black-eyed Susan" are among them.

Alexander Pope. Pope (b. 1688; d. 1744), writing of himself, tells us that

> As yet a child, now yet a fool to fame,
> I lisp'd in numbers, for the numbers came.

Many critics maintain that they came too easily. These are they who hold that Pope's polish is a proof of his unpoetic soul. Pope was obviously influenced by Dryden. But Mr. Gosse insists on Pope's great indebtedness to Boileau. "The French satirist had recommended polish, and no one practised it more thoroughly than Pope. Boileau discouraged love poetry, and Pope did not seriously attempt it. Boileau paraphrased Horace, and in so doing formulated his own poetical code in 'L'Art Poétique'; Pope did the same in the 'Essay on Criticism.'" Mr. Gosse carries the parallel much further, though this goes far indeed, and English poetry must admit a great debt to the French writer who, at an important moment in its development, inculculated in his English pupil purity and decency of phrase. The son of a London linen merchant, Pope was excluded from public school and university by reason of his father's religion; and the result was that he was largely self-taught.

Pope's Characteristics. By Pope's writing we are able in a large degree to judge his time. "He did, in some not inadequate sense," writes Lowell, "hold the mirror up to Nature. It was a mirror in a drawing-room, but it gave back a faithful image of society, powdered and rouged, to be sure, and intent on trifles, yet, still, as human in its own way as the heroes of Homer in theirs." His work contains gems not of his own mind but gems reset, admittedly with skill, and therefore of permanent value.

His crippled body affected his outlook on the world. His "Essay on Criticism" was written out in prose before he was twenty years old, and then versified. It has been described as "unquestionably the finest piece of argumentative and reasoning poetry in the English language." Professor Courthope has invited attention to the remarkable analogy presented by the poetical career of Pope to the contemporary change in the English Constitution and the parallel ascendency of Walpole in politics; and maintains that Pope "gave to the couplet as inherited from Dryden a polish and balance which perfected its capacities of artistic expression, perhaps at the expense of its native vigour." Judged by what he was and what he did, not by what other poets were and by what *they* did, Pope will be found to fill a definite and distinguished position in the evolution of English letters as they reflect English life.

Thomson, Gray, and Goldsmith. In the poetry of JAMES THOMSON (b. 1700; d. 1748) is heard an echo of Spenser. This echo is characteristic of much of the poetry of the eighteenth century. Thomson affords relief from the works of Pope by singing of Nature sincerely, if in a somewhat affected style. His chief poems, "The Seasons" and "The Castle of Indolence," prepare the way for the beautiful odes of WILLIAM COLLINS (b. 1721; d. 1759) and the scholarly writings of THOMAS GRAY (b. 1716; d. 1771), whose "Elegy written in a Country Churchyard" (Stoke Poges) did for "the rude forefathers of the hamlet" what Pope accomplished for the fashionable folk of the town. Gray wrote little, but what he wrote was written supremely well. He was a man of leisure and refinement, the son—like Milton—of a scrivener. He drew inspiration from Milton and Dryden, and is one of the harbingers of

Wordsworth. Mention may here be made of ROBERT BLAIR (b. 1699; d. 1746), who wrote a sombre poem called "The Grave"; WILLIAM SHENSTONE (b. 1714; d. 1763), whose "Schoolmistress" is a tender tribute to a Leasowes teacher, Sarah Lloyd; MARK AKENSIDE (b. 1721; d. 1770), whose "Pleasures of the Imagination," once popular, is too heavy and didactic to appeal to the modern reader; and OLIVER GOLDSMITH (b. 1728; d. 1774), a name universally beloved—and, in truth, that of a citizen of no one country, but of the world.

The Works of Goldsmith. Let none apply too scornfully or carelessly the term "bookseller's hack," for Goldsmith—poet of "The Deserted Village," writer of that inimitable novel "The Vicar of Wakefield," and author of the equally delightful comedy "She Stoops to Conquer"—was a bookseller's hack. Goldsmith had, in generous measure, the saving grace of humour, with infinite tenderness and graceful delicacy of thought. "No writer in the language," says Professor Masson, "has ever surpassed him, or even equalled him, in that witching simplicity, that gentle ease of movement, sometimes careless and slipshod, but always in perfect good taste, and often delighting with the subtlest turns and felicities, which critics have admired for a hundred years in the diction of Goldsmith." In some respects he touches the heart of man, and especially of the literary man, more surely even than Charles Lamb does. Ireland, that gave us a Swift, also gave us Oliver Goldsmith. The fact is one to be held perpetually in grateful remembrance.

William Cowper. Cowper (b. 1731; d. 1800) makes his appeal to young England in the nursery. Where is the English child who has not treasured the ballad of "John Gilpin"? Cowper missed the sweet influences of a mother's love. He laboured from infancy under the disabilities of a weakly frame, and for a time under the terrible burden of insanity. His first masters were Milton and Cowley; his music was also inspired by the works of Thomson. His initial essays in verse were written under the personal influence of the Rev. John Newton, curate of Olney, in Buckinghamshire, a converted slave trader of melancholic temperament. Cowper's sad experiences of public school life are reflected in his "Tirocinium; or, a Review of Schools." How his famous didactic poem, "The Task," came to be written makes a charming story of woman's influence. Cowper, cheered by the sympathetic friendship of Lady Austen, had written the Ballad of "John Gilpin" after Lady Austen had recounted the legend to him; and she then asked him why he did not try blank verse. "I will," he replied, "if you will give me a subject." "Oh," was the rejoinder, "you can write on any subject. Write on this sofa." This was the germ from which sprang "The Task." Thus succinctly Arnold has indicated Cowper's treatment of Lady Austen's theme: "After having come down to the creation of the sofa, fancy bears him away to his school days [at Westminster], when he roved along Thames' bank till tired, and needed no *sofa* when he returned; then he becomes dreamy, traces his life down the stream of time to the present hour, noting what has made him happy, stilled his nerves, strengthened his health, raised his spirits, or kept them at least from sinking; and finds that it has been ever the free communion with Nature in the country." Many charming descriptive passages are interwoven.

It is in "The Task" that is found the line:

God made the country, and man made the town.

Cowper's Contemporaries. Among these were JAMES MACPHERSON (b. 1736; d. 1796), the reputed author of "Ossian"; CHARLES CHURCHILL (b. 1731; d. 1764), author of the satirical "Prophecy of Famine"; MICHAEL BRUCE (b. 1746; d. 1767), who wrote that delightful lyric, "Ode to the Cuckoo"; and THOMAS CHATTERTON (b. 1752; d. 1770), who wrote the "Rowley Forgeries" at the age of sixteen.

The sleepless soul that perished in his pride!

Chatterton came to London full of hope and confidence in his extraordinarily precocious powers. He died of starvation and poison in a wretched garret, and was buried in the paupers' pit of Shoe Lane Workhouse.

Robert Burns. Scotland's national bard (b. 1759; d. 1796) was a poet of the people, who wrote for the people. It was Professor Blackie who declared on his deathbed, "The Psalms of David and the songs of Burns—but the Psalmist first." "To Burns," said Lord Rosebery, "we owe it that we canny, long-headed Scots do not stagnate into prose. His genius and character are the Gulf Stream which prevents our freezing into apathy and material life. . . . He never fails us. We rally regularly and constantly to his summons and his shrine. His lute awakens our romance, and charms the sunless spirits of darkness. He is the influence that maintains an abiding glow in our dour character." Burns followed no "master" and founded no "school." He stands alone, and in his own domain is without a rival. For the best interests of literature let the young student study such poems as "The Cottar's Saturday Night," "To Mary in Heaven," "To a Mountain Daisy," "Robert Bruce's Address to His Army," "To a Mouse," "Hallowe'en," "Tam o' Shanter," and "The Jolly Beggars," and leave the story of the poet's life for more mature consideration. From the works named may be gained sufficient insight into the humanity, the humour, the pathos, and the lyrical genius of their author. The songs of Burns must appeal to all. They are rich and rare. "The Banks o' Doon," "Green Grow the Rashes O," "The Birks of Aberfeldy," "John Anderson," "Highland Mary," "My Heart's in the Highlands," "Auld Lang Syne," "For a' That and a' That," "The Lass o' Ballochmyle"—these are part of every Scotsman's birthright. But the poetry of Burns is not only a Scottish possession: it plays no insignificant part in the formation of the British character.

J. A. HAMMERTON

JOHN MILTON DICTATING—FROM THE PAINTING BY FORD MADDOX BROWN

Duties and Salaries of the Municipal Finance Department. Training, Qualifications, and Examinations.

THE MUNICIPAL TREASURER

The financial staff of a local authority is less liberally remunerated, on the whole, than that of the town-clerk—the branch we last considered. The explanation, doubtless, is that many subordinate positions in the accounts department are ordinary clerical appointments, while the town-clerk's staff requires special training, only an expert being able to perform satisfactorily the duties of a committee or election clerk. Leading financial positions, however, as we shall see, need quite distinctive knowledge and abilities, and are in consequence correspondingly well paid.

The Head of the Finance Staff. There is a good deal of diversity of practice as to the title and duties of the head of the finance staff. To quote a distinguished authority, who is himself holding such a post in a prominent county borough, "The chief financial officer of a corporation is styled either Comptroller, Treasurer, or Accountant, the duties of each being of a somewhat similar nature. The position of treasurer is, however, the statutory one, and the majority of corporations are now appointing their leading financial officer in that capacity." In many instances the staff includes both treasurer and accountant, the first holding the senior rank. In some municipalities the two offices are united in a single official; while others, again, place the control of their finance department under the borough accountant, and employ a member of a banking firm or the manager of a bank as their nominal treasurer.

The Treasurer's Duties. The chief of the financial branch holds a very responsible office. He is in general charge of the revenues and disbursements of his authority, such large sums passing through his hands that security to the extent of £5000 or £10,000 is usually required of him. As expert adviser to the council on the financial side of their many operations, he has an anxious duty to perform. Not only is he consulted as to the conduct of such matters as raising and extinguishing loans, issuing stock, and fixing terms and rates of interest; the soundness or otherwise of important "municipal trading" schemes, and the proportion of expense which these undertakings should bear, are among the grave questions on which his opinion is of weight. He must further be familiar with the complex system on which municipal accounts, as a whole, are kept, and the bookkeeping methods best adapted to the special needs of trading and other departments. These qualifications can only be acquired by a wide experience of municipal finance in all its branches.

As already pointed out, no absolute distinction can be drawn between the treasurer and the accountant; but where both offices are separately held under the same local authority, the treasurer's concern is mainly with finance and securities, the accountant's with bookkeeping and office checks on expenditure. In these circumstances the former official holds the more distinctly professional appointment; otherwise, the requirements for either position are practically identical, and we may conveniently defer the discussion of their qualifications in order to deal with both together.

The Influence of Municipal Trading. We have seen, in considering electrical and gas engineering and other appointments, that there has been in recent years an astounding development in the commercial or "trading" activities of local authorities, and there appears to be every prospect of a continued increase for many years to come. The bearing of this development on the finance and accounts staff is too direct to be overlooked. In the words of the expert already cited, "The very large commercial undertakings which are now being carried on by the municipalities throughout the country have, during the last few years, materially increased the responsibilities of the finance department, and the importance of its work becomes more and more manifest from year to year." The growth of a department involves a greater number of highly paid offices in it, and thus affords increased scope for members of the staff who show ability.

Treasurers' Salaries. This fact is instanced by the case of the London County Council's chief financial officer, the Comptroller. So greatly has the work of his office increased during the past nine years that his salary has advanced in that time from £2000 to £2500 a year. The latter is an exceptionally high figure, of course, though it is surpassed in at least one instance. The Chamberlain to the City Corporation, who acts as its treasurer and banker, receives £3000 a year. It should be added that he is an exceptionally able financier, having gained invaluable experience by many years' partnership in a great banking firm. Under less distinguished authorities the income of county and borough treasurers varies considerably, ranging from £500 to £1600 a year, according to the size of the local body they serve and the importance of the works it controls. Deputy treasurerships are remunerated at about one-half or three-fifths of the salaries attaching to the principal posts. The treasurer to the Manchester Corporation is paid £800 a year, and the cashier £400 to £500.

Municipal Accountancy. Where the accountant's functions are distinct from those of the treasurer, they may be summarised as

comprising the direct charge of the accounts staff, and a general supervision over the bookkeeping in every other department, so as to safeguard the local authority from losses through carelessness or fraud, and to facilitate the periodical inspection of the accounts by the Local Government Board auditor. It is the accountant's duty also to control the collection of moneys, and to frame from the various departmental accounts those elaborate financial statements which are necessary to disclose the position of the county or borough as a whole. The work thus briefly indicated is more complex than anyone who has not explored the mazes of Local Government accounts would be disposed to believe. Its proper performance needs something like a gift for figures, as well as a close familiarity with municipal accounting methods, and inexhaustible patience and alertness.

Owing chiefly to the difference of duties already pointed out, accountancy posts, as a class, are less liberally repaid than treasurerships. They range in value from £250 to £1000 a year, the latter figure being rarely exceeded.

The Requisite Training. Candidates for county or borough treasurerships are generally required to have qualified as professional accountants, and to be thoroughly versed in municipal accounts and finance, as well as accustomed to control a staff of clerks. For the municipal accountant the same conditions apply, except that in his case a professional diploma is not always insisted upon, vacancies being filled by the promotion of experienced and deserving assistants or accountants' clerks at least as often as they are advertised or reserved for "admitted" men.

The shortest and surest route to a principal position of either grade is to enter as an articled clerk the office of a borough treasurer or accountant who is a Fellow either of the Institute of Chartered Accountants or of the Society of Incorporated Accountants and Auditors. These are the two general accountancy bodies whose diplomas carry much weight within the municipal world as well as without. A schedule of their examinations will be found on page 136, in the Clerkship and Shorthand course.

In this way the student, while gaining valuable experience in the practical side of municipal accounting, can prepare for the examinations admitting to the Associateship, and ultimately to the Fellowship, of one of the two institutions we have mentioned.

On the expiry of his articles he may look with some confidence for an assistantship, and later for a principal appointment. Such a direct road to promotion should on no account be neglected by the fortunate youth to whom a moderate premium and a term of service without a salary present no insuperable obstacle.

On the other hand, the same advancement is within reach of a member of the clerical rank and file who has neither means nor influence to smooth his path, and this fact constitutes the great counter-advantage of the finance branch as compared with more highly paid departments. The post of borough engineer, medical officer, or surveyor, for instance, is almost out of reach of those who are not specially and expensively trained from the start; but there is no reason why any aspirant for a leading financial post should not—with good abilities, a fair general education, and an aptitude for figures—attain his ambition while supporting himself throughout.

One Way of Success. It will be worth while to consider shortly the steps by which a clever lad may pursue from small beginnings such a career as has been indicated. An early start is perhaps the foremost essential for success under these conditions.

Years of practical experience are needed to master the complexities of the many branches of municipal accounting; and local authorities, finding that their best finance officials are those who have been trained to the work from their youth, are reluctant, as a rule, to appoint untrained clerks to these duties after the age of 25 at the latest.

The ambitious youngster will probably gain his footing on the first rung of the ladder of promotion between the ages of 15 and 18 by a position as office youth or junior clerk on the borough treasurer's or accountant's staff. Here he must take every opportunity that arises to master the details of account-keeping, supplementing this practical training by evening classes in bookkeeping, banking, and commercial subjects. In this way he will be qualified for the post of office clerk or junior bookkeeper when a suitable vacancy arises; and after a few years' further experience in that capacity he should be ripe for promotion—either in the same office or by transfer—to the grade of chief bookkeeper or accounts clerk.

Professional Qualifications. Meantime, it will be advisable for the budding accountant to direct his studies towards obtaining a recognised qualification. We have seen that this is not an indispensable step, but, on the other hand, it offers no colossal difficulties, and, in view of the great value of a professional accountancy diploma when competing for a leading appointment, even the hardest-worked accounts clerk should not neglect the opportunity of gaining it for any but the gravest reasons.

Of the two accountancy associations already mentioned, the Institute of Chartered Accountants admits to its examinations only those students who have served at least three years' articles to a member. For such a self-dependent youth as we have in view, this is an absolutely prohibitive condition, unless his office chief should be himself a chartered accountant, and would grant him his articles on exceptionally favourable terms.

The Society of Incorporated Accountants and Auditors, however, accepts candidates, other than articled clerks, who have served a specified term of years (six for the intermediate, and nine for the final examination) as clerk to a municipal or other public accountant. The official who is resolutely seeking a professional status may, therefore, find it expedient to take this Society's final examination as soon as possible after reaching the minimum age of 25. He must then

wait for promotion to a principal clerkship before he is eligible for the Associateship or Fellowship (A.S.A.A. or F.S.A.A.).

There cannot be two opinions as to the value of this qualification for municipal work. The Secretary of the Society of Incorporated Accountants and Auditors states that "the post of borough treasurer or accountant to the large majority of the boroughs throughout the country is held by members of this society, the diploma of which carries a great deal of weight in any competition for such an appointment."

Diplomas for Municipal Officers. There exists, for the benefit of municipal officers alone, a similar society, whose examinations are of especial value, because they are directed to the particular branches of accountancy with which such officials are concerned. The society to which we refer is the Incorporated Institute of Municipal Treasurers and Accountants.

Membership of this body is widely recognised as a proof of efficiency, many local authorities, when advertising a vacancy for a treasurer or accountant, accepting that qualification equally with the F.C.A. or F.S.A.A. diploma. The young student of Local Government accountancy will, therefore, probably be attracted to an I.M.T.A. certificate in preference to those of the other two bodies named. The examination subjects, fees, and other particulars are set out in the accompanying schedule. Examinations, both primary and final, are held yearly. The centres are determined after all applications are received, but always include London and one Northern town, at least.

Age Limits. Many chief accountancy positions are held by young men of less than 30. One such post in a busy London borough, at an initial salary of £350 a year, was won by a public accountant of 31; and another was restricted to candidates between 28 and 35 years of age. More usually, however, the upper limit is extended to 40 or beyond.

The post of professional auditor, it may be mentioned in passing, is often held by an accountancy firm in private practice, who provide their own staff of clerks for the audit, and are paid by fees varying from a hundred guineas to nearly ten times that sum.

Rate Collector. For the office of rate collector, no particular qualification is prescribed. The only essentials are integrity, exact bookkeeping, and a general knowledge of the way in which rates are made and recovered. Applicants are not restricted to any one department, and, indeed, are sometimes appointed without previous municipal experience of any kind. The best training, however, is afforded by a clerkship on the rating staff, and from this class the ranks of the collectors are largely recruited. These officers must reside within the district for which they are appointed, and must provide an office and safe. They are usually required to undergo a medical examination before appointment, and to give security for their honesty. Their duties are monotonous, and occasionally distasteful, but considering that no special knowledge or training is needed for the post, they are well paid. The method of remuneration varies; sometimes it is a fixed and at others a progressive stipend, while the income of some collectors varies with the number of assessments on which the rates are recovered. For the smaller districts, £150 to £200 is the usual salary, and for the larger areas £250 to £350, and sometimes £400. The City Corporation pays its chief collector £500 a year, and even this is occasionally exceeded. But, although the rate collector is well remunerated, he has rarely any prospects of advancement. "Once a collector, always a collector," is an axiom of the service. ERNEST A. CARR

MUNICIPAL TREASURERS AND ACCOUNTANTS

Examining Body, Time, Grade, Place of Examination	Subjects of Examination	Fees and Age Limits
PRIMARY INSTITUTE OF MUNICIPAL TREASURERS AND ACCOUNTANTS (INCORPORATED)	1. FINANCE AND ACCOUNTANCY: Arithmetic and algebra, up to quadratics. Bookkeeping and accounts. Local authority finance. Auditing. 2. LAW: General principles affecting municipal treasurers and accountants, including statute and common law, real and personal property; mortgages, deeds, agreements, etc., contracts, local rates, duties of overseers, borrowing and rating under certain statutes. NOTE.—Candidates must have served three years in finance department of municipal or kindred authority. Successful candidates become students of the Institute.	£1 1s. See note
FINAL Each October at two (or more) centres—namely, London and in North of England	1. FINANCE AND ACCOUNTANCY: Advanced bookkeeping and accountancy. Local authority finance. Auditing, including systems of internal check. 2. LAW: Municipal Corporations Act, Public Health Acts, Local Government Acts, etc. Duties of overseers, making and enforcing rates, audit of accounts: (a) audited by Local Government Board auditor; (b) not so audited; mortgages, deeds, agreements, and the like.	£2 2s. See note

NOTE.—Candidates must be Associates of the Institute, or of the Chartered or Incorporated Accountants' Societies; or Students of two years' standing, or, if they have served five years in finance department, of one year's standing; or must have served six years in municipal finance or audit work, and have passed the Primary examination.

Recent Wonderful Discoveries about Cell Life.
Protoplasm, "The Physical Basis of Life."

THE STRUCTURE OF THE CELL

LESS than a hundred years ago there was established the epoch-making doctrine which was known as the cell theory. The microscope revealed the fact that living beings are composed of units called cells; some may only consist of one cell in all, some may consist of billions, but even the whale or the elephant was itself once a single microscopic cell.

The first discoverers, who were botanists, were impressed with the *walls* which make the cells, and thought that these walls were the really important thing. They are not. In animals, as a rule, the cell walls are indistinct or absent, though usually so very conspicuous in plants. What really matters is the *contents* of the cell, and the cell itself is entirely subsidiary. But the word has come to stay, and may well do so, if we always remember that when we speak of "the living cell" we really mean the contents or *inhabitant* of the cell.

The smallest possible portion of living matter, it was believed and taught until very recently, is the cell. Hence it was "the unit of life." A living being might consist of more cells than one, but it could not consist of less. The typical cell, as it may be seen in the amœba, or the simpler and less common type of cell seen in microbes, was looked upon as the *minimum* of life. As we have already seen, that view cannot now be maintained. Just as the chemists have had to recognise a lower order of unit, the electrons, which combine to make up what they had thought to be the ultimate unit, the atom, so the biologist has to recognise a lower order of living unit within the cell. Indeed, those units must be the actual architects of the cell itself, or the architect's instruments.

As we advance in our century, we continually find that we are coming to what Herbert Spencer foresaw and rightly defined, against the voices of the majority, in his century. He declared that, as the laws of heredity above all showed, there must be an ultimate living unit which lay *between* the larger unit called the cell and the smaller not-living unit called the chemical molecule. Some combination of such molecules there must be within the cell—indeed, there must be myriads of them—which he called "physiological units," and which must be looked upon as the *real* units of life or of living substance.

We must clearly appreciate the meaning of Spencer's—which is now everybody's—idea before we proceed to study the cell as a whole. The student might well suppose that our arguments as to living units within the cell were rather abstract and theoretical, and that enough had already been said about forms of life simpler and smaller than any microscope can show, when we were discussing the origin of life. But all the problems of heredity lie in front of us, and when we reach them, and try to interpret the astonishing facts which experimental breeding and the study of human pedigrees have revealed, we shall find that the idea of living units within the living cells—in this case within the living germ cells from which all individuals spring—is essential for any comprehension of the facts at all. Since the existence of such units was proved by Spencer, a dozen authors at least, all studying heredity, have followed him, each with a new name for these units—"micellæ," "pangenes," "determinants," "factors," "biogens," and many more—but the sheer fact of their living existence within the cell is enough, and very much, for us to learn and remember.

This being clear, we may proceed to the study of the cell as a unit in itself, and our study will be wholly profitable now that we have begun it by the understanding that the simplest living thing which the microscope can show us is really infinitely too complicated for microscope to follow or mind to imagine. A living cell is really a little world, a microcosm, to use the famous old word, and our best science can give only the crudest outlines of its real structure and organisation, to say nothing of the indescribable, unimaginable forces that have built it up.

Cytology—The Study of Cells. When living beings that have reached the cell stage, and can be seen by the microscope, consist of only one cell all their lives, we call them *unicellular.* On the theory that they are the first or earliest of living beings—which we are now sure they are not—we may apply the Greek adjective *proto-* to them. Thus the one-celled animals are called *protozoa,* and the one-celled plants are called *protophyta.* The single cell that we call an amœba is thus the whole animal. But in a speck of our blood, no bigger than a pin's head, there are several millions of living cells, and the total number that make our body is uncountable and unthinkable. Well may we call the beings whose bodies are thus composed *multicellular,* as contrasted with the unicellular protozoa and protophyta.

The English form of the Greek word for a cell is *cyte,* and so we speak of *leucocytes,* the white cells of the blood. But cells are so important that the study of them needs a special name, and it is now known as *cytology.* All over the world, with microscope and chemical reagents, men are pursuing this science of cytology, observing and analysing and experimenting upon cells, dead and alive.

It is a fact of high importance, forgetfulness of which has led to many errors, that most of our study of cells has been devoted to dead cells. That is, or was, inevitable. We take a drop of sputum or expectoration from a consumptive person, and stain it, so as to reveal the tuberculous microbes which have invaded his lung. The student looks and describes these microbes as "red," forgetting that what he sees are their corpses, stained with the red dye which reveals them best. No one has ever seen a living tubercle bacillus. The same is true, of course, when we study the cells of the brain, and was true until a year or two ago for all observations upon the liver cells. They must die, and then be prepared and *changed* in various ways, before we can see them.

Watching Cells Grow. The cytology of today has advanced far beyond the stages reached in the nineteenth century just because devoted students have made up their minds that they must somehow study the living cell in *life.* Astonishing work has been done, especially in America, and is largely due to the genius of Professor Carrel, a young Frenchman who works in America, and has lately earned a Nobel prize. These workers observe the conditions of light, temperature, moisture, nutrient fluid, and so forth under which cells will retain their lives even when they are removed from the body to which they belonged. Thus minute portions of liver and spleen or kidney, of the growing heart of an embryo chicken, and many other kinds of cells, are now being observed *in life.*

Cinematograph pictures have been taken of them, perhaps at intervals of twenty minutes, and have then been put through the lantern at the usual speed, so that the observer sees upon the screen, in a few seconds, the actual cell division and growth which occurred in, say, the heart of an embryo chicken, and which may actually have occupied a number of days of its development.

Highest of all in practical and poignant importance is the study of isolated cancer-cells, living and multiplying for days or weeks, which is now proceeding on these lines. And while cytology is thus advancing in respect of the cells, normal or morbid, that are found as part of the bodies of the highest animals and plants, no less rapid is the development of science in a wholly different direction.

The Protozoon, Man's Greatest Enemy. Only a decade or so ago, scarcely anyone was studying the protozoa. The amœba, the typical protozoon, had been closely studied and written about a thousand times, and the interest of the subject seemed to have been fully exploited. Then there began that astonishing series of discoveries in Tropical Medicine which has already built the Panama Canal, and will soon change the face of the tropical world. Prof. Laveran, still alive and working in Paris, had found an animal cell, a kind of protozoon, in the blood of malarial patients several years before, but the next steps could not at once be discovered. Our own Manson and Ross took them.

A large number of protozoa are now known as the causes of several of the most important diseases, including malaria, one form of dysentery, and even more dreadful enemies. Obviously, our interest in these humblest animals must be vastly greater than even such a strange and wonderful creature as the innocent amœba of the ponds could excite. Today Proto-zoology is one of the most valuable departments of biology, and all over the world special chairs and laboratories are being founded for the sole purpose of studying these unicellular animals alone. Man's absolute mastery, if he chooses to use it, over all those that may injure him is now only a matter of a few more years.

What the Microscope Reveals. Let us now see what the microscope reveals as to the structure of one of these simplest animals, some of which have for ages destroyed countless millions of the "paragon of animals"—himself; or, for it matters little, we may study a typical cell from almost any part of our own bodies. In essentials we shall find that the living cell is one and the same thing everywhere, though the individual details, which the microscope can only begin to show, must be very great when we remember that a living cell may be a micro-coccus, or the cell which will multiply and become a man.

We said that the cell wall is much more marked, as a rule, in the cells of plants than in those of animals. When the microscope was still very primitive, those walls became visible, and hence the name cells at all. But later observation, with the modern microscope, has shown that the cells of plants, contrary to appearances, are really much less separate and distinct from each other than those of animals. The walls of the cells of plants are now known to be perforated at many points, and through the perforations the protoplasm or living material of each cell communicates and becomes continuous with the protoplasm of its neighbours.

The Shape of a Cell. The pictures of cells, or the views we get through the microscope, must not deceive us as to their real shape. They are not flat things, but solid. What we see under the microscope is only a view at a certain plane or level. The tissue of wood or liver or brain, or anything else, has been cut through, and we see the section or cut surface. But cells are really solid things of three dimensions, and the typical shape of a cell is that of a globe or sphere.

Actual shapes vary immensely for different purposes, but a round ball of living matter is the typical cell. Where cells have to be packed together to make a larger structure, like the stem of a plant, the globular shape will tend to be squeezed into something rectangular, cubical, or oblong, so that the straight side of one cell is also the straight side of one of its neighbours.

The Construction of Plant Cells. Now, in the case of the plant we have lately learnt that the cell boundaries or walls are perforated on all sides, and the protoplasm is continuous through the perforations. In fact, if the cell walls could be taken away without disturbing anything else, we should find that they are really a subordinate, mechanical kind of steel skeleton for architectural purposes, like that of a modern building. Without them, we should find that the plant was really an all but continuous mass of protoplasm, with denser kernels, or *nuclei*, as they are called, distributed at regular intervals all through it. These nuclei, about which we must inquire most carefully, are real and separate, but the general protoplasm of the cells of a plant belongs almost as much to one cell as another.

This recent discovery is of the greatest importance. First, it teaches us that the structure of a plant, on the whole, is distinctly lower in type than that of an animal, for its constituent cells have far less independence and separateness of function. The contrast is significant when we think of the body of an animal, the blood of which, to take one instance, contains billions of really complete and separate cells, each of which can move and live and do things independently of the rest, though in the service of the whole.

The Mystery of the Plant. And further, if an animal body is really to act as *one thing*, its parts must somehow be co-ordinated. There must be a central government and a kind of telephonic or telegraphic machinery, or everything would soon become chaos. So in the animal we find a "central nervous system," and nerves that convey orders and requests to and from every part of the body. What about the plant? No plant has a nervous system at all, nor even the vestige or trace or barest equivalent of one. Yet a plant behaves as a single, unified thing, with a single purpose—on a vastly lower plane than an animal, of course, but still in an easily demonstrable way.

Many plants, to take a striking case, are what we call "sensitive"—all living beings are sensitive, really—and if the tip of a leaf be touched, the plant will roll up the whole leaf; or, in nearly all plants, the leaves will turn, as far as possible, in order to face the sun as it moves across the sky, for thus the chlorophyll of the leaf will get the maximum of sunlight to use. If the plant has no nervous system, neither eyes, nor senses nor brain nor nerves, how can it behave in this way?

A SENSITIVE PLANT, SHOWING HOW IT SHRINKS UP AFTER BEING TOUCHED

A Protoplasmic Telephone System. Well, we must not be so sure that the plant has no eyes, or something which plays the part of eyes; but even supposing that the presence of light-appreciating organs has been demonstrated in the leaves of plants—as it has—how does the message travel to the part of the plant which twists the leaf?

A few years ago a distinguished Indian physicist satisfied himself that he had solved the problem by demonstrating the existence of real nerves in plants, but it is now clear that his conclusions were erroneous. The truth must be that the different parts of the plant are brought into communication by means of the protoplasmic threads which connect each plant cell with its neighbours, through the perforations in the cell walls.

In the discovery of these threads we have the explanation of the fact that the plant can do without nerves, and is yet able to act as a single thing. All the recent experiments on the

perception of pressure, of light, of the direction of the earth (as when a growing plant is turned upside down and the root curves over toward the ground)—all of these wonderful discoveries in plant physiology teach us that the little holes in the cell walls of a plant are essential to the plant's unified existence at all, as an organic whole.

Now let us turn to the cell walls in the case of animal cells. Take, for instance, a red cell from the blood of any one of the higher animals. It has no visible wall at all, but of course, it has a surface. On examination we can learn a little about this surface. There must be some sort of "skin" or membrane, bounding the cell, and we infer that this membrane is elastic, for the cell can be noticed sometimes to undergo deformation by being squeezed, and after the pressure is removed it regains its original shape.

GRANULAR PROTOPLASM IN THE CELLS THAT FORM SIMPLE ALGÆ

But there is much more to say about this invisible membrane that encloses the cell, and one of the most important problems to which modern cytology devotes itself is the structure and function of such cell walls as this.

The Structure and Function of Cell Walls. Whatever this membrane be made of, it must not be a kind of "waterproof" coat, which lets nothing through. No matter what kind of cell we are talking about, it is a living being, which must feed and breathe and excrete (that is to say, get rid of rubbish), or it will die. In other words, all manner of things, liquid and must be able to pass, in either direction, ugh the limiting membrane of the cell. It must be permeable. But if it were like a net of muslin, freely allowing all kinds of gases and liquids to pass in either direction, the cell would soon die. It would be a leaky cell, and it would soon be a cell poisoned from without. No living cell could thrive, or could have been develop which did not have some control over what should enter it and what should leave it. Inquiry shows that the boundary of a typical animal cell is what is called a *semi-permeable membrane*; it is *permeable on terms*, and upon those terms the life and health of the cell depend.

Here is a field for research and experiment which is limitless in possibility, and which men have only just begun to study. All the resources of physics and chemistry are required, for we are here at the junction between them, which is called physical chemistry. We must study the laws by which gases and liquids of different kinds, placed next one another, begin to intermix; we must experiment with all kinds of semi-permeable membranes, and we must learn all we can about the phenomena which the physicists call *surface-tension* and *capillarity* and *osmosis*.

In time we shall begin to understand how and why the cell maintains its life and health, how it grows, how it grows old, and dies. We are here very near the heart of the physical problems of life. So much, then, for the cell wall, through which occur all the processes of exchange with the outer world upon which the life of the living contents of the cell depends.

The Contents of a Cell. And now for those contents, which Huxley taught us to call "protoplasm, the physical basis of life" This is, of course, the most wonderful substance in the world, and man will never know enough about it. No microscope can ever be as powerful as we should wish, for the very nature of light imposes a limit upon the possibilities of any microscope. Chemistry will help us greatly, but even that ancient and splendid science must grope almost in the dark when it deals with anything so complicated and mysterious as protoplasm. Today we are just realising that the confident and dogmatic way in which protoplasm used to be described a generation ago was quite unwarrantable. We have learnt much since then, and know how little we know.

In order to give ourselves a fair chance we must try to put aside anything which is inside the cell, but is not really part of its living protoplasm. We soon find that every living cell contains various things which are not part of its living substance—though no man can say, in many cases, what is the exact relation of the living substance to these things. In the cell we find oxygen and carbonic acid, always. The carbonic acid is perhaps dissolved, more or less simply, in the water which constitutes by far the greater part of the bulk of protoplasm. It is not a constituent of protoplasm, but one of its excreta, the poisonous things which it produces and must get rid of. At once the careful student will remember a great exception—the green cell which uses carbonic acid as a source of food and decomposes it. That is true, but it is doubtful whether the carbonic acid as such ever gets inside to the protoplasm of the cell at all. It is probably decomposed at the very surface of the cell, where the sunlight is strongest, and where the chlorophyll grains are placed.

Then the cell-protoplasm always contains oxygen, by which it breathes and burns. This

oxygen, however, is not really a part of protoplasm, though we know that protoplasm can store oxygen up, to some extent, within its substance, in mysterious ways which no chemist can describe. An isolated muscle, with no blood running to it, can be made to contract in an atmosphere of pure nitrogen, and will yet yield carbonic acid, the result of the combination of carbon and oxygen. There must, therefore, have been a store of oxygen somehow preserved within the protoplasm of the living cells which make the muscle, and which shorten when the muscle acts. All that the chemists can yet say is that the oxygen is used by means of a ferment or ferments in the living cell, and that the respiration of protoplasm, the fundamental act of life, is *intra-molecular ;* the oxygen does not reach the surface of the cell and burn it, as the surface of a lump of coal or wax would burn, but is first all but incorporated within the living substance itself.

Many other substances are found within the protoplasm of the cell—mostly excreta, about to be cast out, or "things to eat," about to be used and built up into fresh protoplasm—for all protoplasm is ever wasting away by its own vital processes, and must be replaced if the cell is to survive. Different specimens of cells show differences in their non-protoplasmic contents. In the amœba we may often see what are simply the indigestible remains of something it has lately "swallowed," by flowing round and enveloping it in "amœboid" fashion. In the malaria parasite we usually see a number of black specks which are made by its protoplasm, but are not part of it. In the green cell, of course, are the chlorophyll grains, also made by its protoplasm, but not part of it.

Protoplasm. Putting all such things aside, we come to protoplasm itself. We look at it under the microscope, and try to discern, in the first place, its structure. Unfortunately, we have great difficulties here. Directly we stain the living cell with dyes, so as to reveal its details, we kill it and *alter* its structure. Different methods of preparation and different conditions of observation yield different results.

Sometimes protoplasm is described as having a physical structure like "foam," sometimes as forming a "network," sometimes as "granular," sometimes as "homogeneous." Perhaps these different descriptions do not matter so very much. We have already seen reason to believe that it is really the chemical structure and composition of living things upon which their properties depend.

The actual visible appearance of cell-protoplasm is probably not very important. In the architectural sense, perhaps it has no very definite "structure," as a house has structure, at all. Its real structure will be something beyond the limits of vision, and consists of the ultra-microscopic chemical molecules which compose it, and of the chemical unions and balancings between them.

The Character of Protoplasm. But at least we can be sure that living protoplasm consists of a *semi-solid structure in a watery medium.* ...er, with the various salts and gases con... in it, always constitutes the greater part of the bulk of the cell, but the protoplasm itself is colloidal in character, semi-solid like glue; and whether it exists as granules or as a network or in a sort of foam-like bubble structure does not matter as much as the microscopists of the nineteenth century used to suppose.

But if we are looking at any typical cell, we find in the centre of it, or, as a rule, at least near the centre, a denser portion, which usually takes more of any stain than the rest, and so shows up well when the cell is prepared with dyes for microscopic observation.

The Nucleus. This is the nucleus—literally the little nut or kernel of the cell, which we have already mentioned—and it has now been proved that this nucleus is really the essential part of the cell, for all the great purposes and needs of life. It is so different from the rest of the cell that its protoplasm requires a special name.

Today we are careful to describe the cell-protoplasm, outside the nucleus, as the *cyto-plasm*, and when we have studied it we pass onward and inward, to study the *nucleo-plasm*, which makes up the cell-nucleus, and contains within itself the central mystery of the Universe [see page 198]. In structure, chemistry, functions, this nucleus is a thing apart. Arguments about the structure of the cytoplasm are probably more or less unimportant, because it may have no visible architecture at all, but at certain times in the history of the nucleus, when it is preparing for the essential function of life called reproduction, it clearly shows a kind of wonderful geometrical patterns, changing in solemn and regular order, like a kaleidoscope; and in the secret of those patterns and that structure lie all the mysteries of reproduction and heredity. We began with the cell wall, but now we have come to "the heart of the matter."

C. W. SALEEBY

AMŒBÆ FEEDING ON DIATOMS

The upper amœba is thrusting out part of its substance to surround a diatom; the lower one has already enveloped some of its prey.

Geographical Advantage. Virtues of English Law. The Export Focus of the World. The World's Middleman.

WHY LONDON RULES BUSINESS

LONDON has grown to be the capital of the most marvellous Empire the world has ever known—the centre of the Imperial Government, the cradle of liberty, and the place from which the finances of the world are influenced, if not controlled.

London possesses the great advantage that as the capital of the Empire it is acknowledged to represent all that Empire's virtues. For centuries the word of an Englishman has been as good as his bond, and this reputation gives London the foremost place amongst the capitals of the world. We do not doubt that for integrity and honesty the metropolis is equalled by the merchants of Manchester, Glasgow, Liverpool, and other great cities in the United Kingdom, but the foreigner can only think of London because it is the capital, and therefore to London he first ascribes that faculty for scrupulous trading and rigid honesty which is also characteristic of the nation.

London's supremacy is based upon the fact that it is the centre of the world's trade. To begin with, London is the export focus of the world. By that I mean that the metropolis, as the result of hundreds of years of trading, has gained the confidence of the whole world, so that goods which come from it bear the London mark, acknowledged as the London guarantee, and as such are accepted by traders all over the globe. To be sure London does not fix the price of everything—cotton is a notable case in point—but experience has proved that to do a big business the firm concerned must have a London office, while the fact that this is a free-trade country gives the port of London an added attraction in the eyes of the foreigner. Millions of pounds' worth of goods are sent to London to be, in turn, exported to other countries, and, of course, London benefits in many ways. There are such things as insurance, brokerage, shipping, and bills of exchange, from which London draws its money and increases its employment. All these things go to consolidate the prestige and position of the metropolis.

Of course, London's great position is primarily due to the long start we had of other nations. The perfect system we have of dealing with bills of exchange, the financial supremacy of the Bank of England, and, indeed, our banking facilities in general, are the result of centuries of work and experience. These advantages are placed at the disposal of anybody who cares to come to London, and we know that they do come in their thousands.

America has found in London the only centre from which to create a world-trade of its own. Even when dealing with the South American Republics, the leading business men of the United States have had to start offices in London in order to increase and develop their export trade. This may seem rather remarkable to the man in the street, but the explanation is simple. In doing a large export trade cash is seldom used, bills of exchange taking their place. Now the South American trader knows nothing of the credit of firms operating in North America, and in turn they know nothing about him. But both parties want to trade, and while one wants cash the other requires credit. In their dilemma they must have recourse to bills of exchange, and for this they must take advantage of London's perfect organisation as well as London's credit and financial standing. A London bill of exchange can travel round the world and practically pass for currency all the time. Thus it is necessary for any firm to get the advantage of London's reputation to open an office in the metropolis.

A bill of exchange is a complicated matter and not easy to explain to the lay mind, but I will take a case in point and use it as an illustration. We will suppose that a firm in Chicago buys a thousand pounds' worth of goods for a customer in England. The goods are shipped, and the Chicago firm gets its bill of lading from the shipper. Now as some weeks must pass before the English customer gets his goods, the Chicago firm would have to wait for the money were it not for the bill of exchange. The Chicago firm, therefore, draws up

a bill of exchange on London in the name of the English customer, payable in three months, and along with the bill of lading takes it to its own bank, where, in exchange, it receives in cash the price of its goods which it has shipped to England. The bill of exchange reaches a London bank in due course, and the latter gets the English customer to endorse it, thereby promising to pay it when it becomes due. In return for this endorsement the bank hands him the original bill of lading, and he gets his goods on arrival. If the bank takes the view that the Englishman is not in a position to pay for the goods, it retains the bill of lading and secures the goods for itself, eventually selling them. Of course this very seldom happens, and every business day throughout the year a vast quantity of the world's merchandise is handed over without any actual payment. A bill of exchange on London may be drawn up in South America on goods shipped from New York to Liverpool or Bradford. The goods may never reach London, but the bill of exchange—that is, the money—must, for London's credit is the best in the world, and traders in every part of it have agreed on London as their centre. It is a wonderful thing, and one of which every Englishman should be proud.

I have explained the bill of exchange at length because it plays such an important and vital part in the business of London. The business of the world is done in cheques and credit—not in gold—and as London is not the product of a few days or years, but the development of centuries, it leads the way.

Another aspect of London which helps to explain its supremacy is its great lending and borrowing capacity. When New York, Paris, and Berlin fail, London comes to the rescue. The big promoters come to London with their brains teeming with gigantic schemes, and it is in London that they find the necessary money to develop these. British capital maintains Canada, it is responsible for many of the most successful enterprises in the great countries of the world, and invariably the headquarters of the lenders of the money have London for an address. When the United Kingdom wishes to speak to the world, or deal with it, London is the mouthpiece and the agent. Weaker nations anxious for more money send to London for it, and if they want money from others they use the influence of London to get it. In this way every year hundreds of millions of pounds are invested by Londoners in the enterprises of the world.

Life insurance and fire insurance—two of the most vital of commercial enterprises—owe their birth to London. The slow growth of centuries is today seen in the perfect organisation and the world-wide integrity of our insurance companies. They have been tested severely along with the insurance companies of other countries, and the result has been to enhance further their supremacy. Take the great San Francisco earthquake and fire. It is admitted that the London insurance companies, by their liberality and promptness of payment, completely vindicated themselves and proved that their supremacy was no mere paper statement. Other insurance bodies looked for quibbles in contracts, threatened litigation and carried out their threats, some even declined to pay, but London made only the usual inquiries, admitted its claims, and paid on the spot. Something similar happened in the case of the Jamaica earthquake and fire. Where the insurance companies of America, Germany, and France failed, London succeeded. Is it any wonder then that, whenever there is a place or a life to be insured, London is thought of first? It is our reputation for fair dealing, our hatred of deceit, our honesty of purpose, that have given British trade the hall-mark of security and has gained for it the confidence of the whole world.

The fixing of the price of the world's commodities is another of London's prerogatives. When the business pioneers burrow into the interior of Africa or Asia and barter goods for the merchandise of the natives, it is not New York, Paris, or Berlin which settles what the enterprising traders can charge for their goods. London sees to that, for London is the gateway through which the goods of the earth pass, and at that gateway are the men who say what value ivory, diamonds, gold, the newest thing in the way of time-saving machinery, and scores of other articles are worth in black and white. They are the experts who know how to reduce every article of commerce to figures on a bill of exchange. Again London is indebted to its forefathers, the men who made it.

While all the products of the earth are passing through London very little money is used. Money is only a token, the real money is the actual merchandise. London

merchants trust one another with thousands of pounds' worth of goods, for credit is the very life of commerce. The many long-established houses in the metropolis whose histories go to make the history of London are worthy of the confidence and respect of the world. They stand for London, and London stands by them. How often do we hear the proverb, " The word of an Englishman is as good as his bond." This is no light saying; it is real, solid truth. Every day in the City hundreds of thousands of pounds change hands with no other acknowledgement than a few spoken words. Merchants trust each other; loans are made on the spur of the moment, ratified by word of mouth. There is no time for formal receipts; everybody is too busy.

The supremacy of England upon the seas is reflected in the returns of merchant ships. We own more sea-going craft than all the other countries of the world put together, and so it is not to be wondered at that the metropolis is the greatest of shipping centres. Rivals grow and develop, but London, big as it is, is developing, too. Experts maintain that this sea supremacy has arisen out of the perfection of our banking system, and they are right. Without the backing of London's wealth, these thousands of ships could not sail the oceans of the world. Great Britain forms the largest trading centre in the world; it is the biggest business, and, therefore, the ships of the world come to its ports, bringing merchandise and taking it away. And London, as the capital, attracts the majority of the ships, making the tonnage of its port the greatest in the world at the present day.

Everything is to be found in London. It is a fact well known in business that the world sends to London when it wants anything in particular. American and Continental firms issue lavish catalogues inviting customers to send for samples or to order the goods. In five cases out of six the merchant has to send to London in order to satisfy the demands of his customers. London is the centre, the very heart of the world's trade.

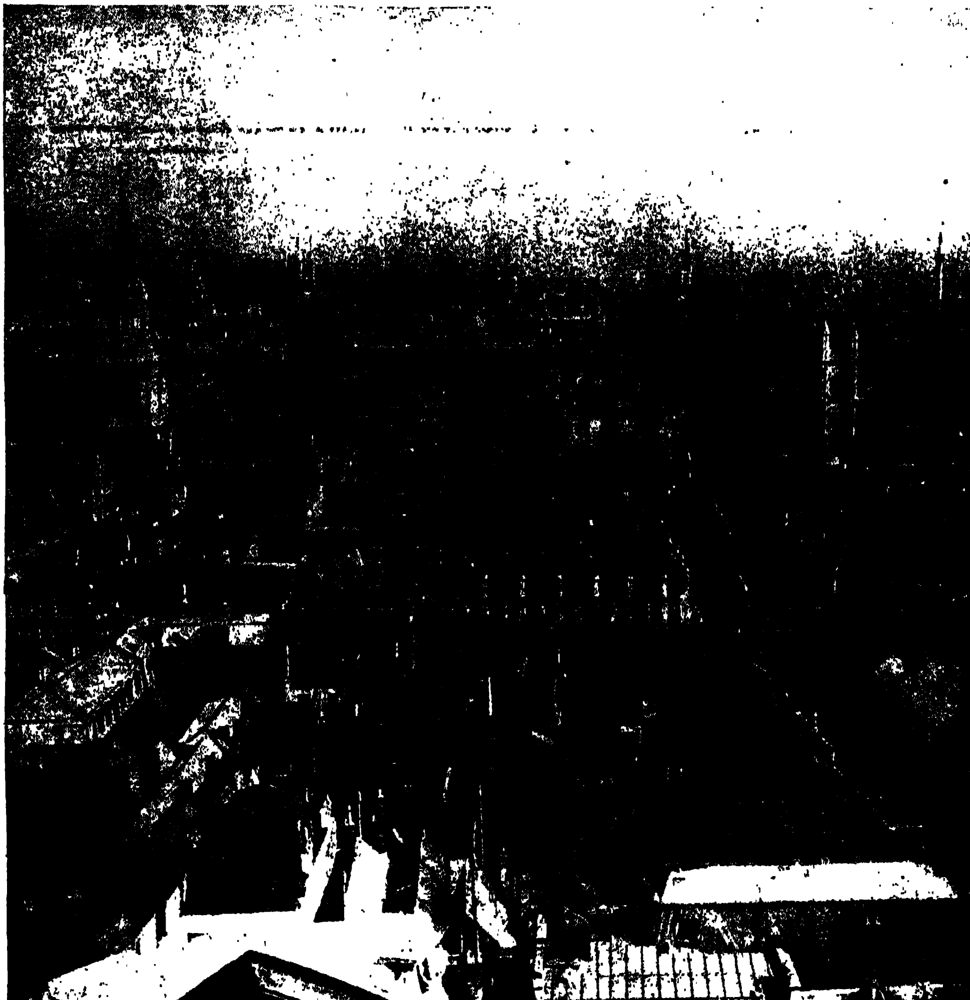
It is a common saying that London is the middleman of the world—in other words, that it does not manufacture; it only sells. This is a mistake, although as middleman the metropolis is unsurpassed. London is a great manufacturing city. Densely populated as it is, and spread over so large an area, its factories and workshops are not so noticeable as the factories of Leeds, Bradford, and other great manufacturing cities, but all the same, London ranks high as a manufacturer, although its supremacy is not due to this. It is significant that many classes of London-made goods carry with them a prestige no other British merchandise enjoy. To the foreign mind London, as the seat of the government and the centre of the Empire's finances, must represent the best, must be, in fact, the best. That is why our manufactures go to the farthest corners of the earth and by their quality help to maintain London's supremacy.

The London Stock Exchange is another of our institutions which have served for models to less favoured nations. Its procedure and rules have been copied by every other Stock Exchange, and although the younger exchanges are making rapid headway, the prestige and position of London's remain undiminished. Nowadays, Wall Street and the Paris and Berlin Bourses have considerable influence on the finances of the world, but when all is said and done London rules the settling. Crises come and go; there are commercial upheavals, panics, failures, and a thousand other ills to which the business of the world is heir, but the London Stock Exchange emerges untarnished. The reason is simple. The committee of the Stock Exchange require absolute obedience to their rules, honourable dealing is enforced, and every member must meet his obligations, while the rule prohibiting advertising, though it may seem conservative and out of date, at any rate serves to make foreigners regard membership of the London Stock Exchange as something of which to be proud. The New York Exchange man may advertise and, of course, he thinks his British confrère ought to do the same, but in his heart he admires that British reserve which enables the Stock Exchange to maintain its hold on the imagination of the people and at the same time earn their confidence and trust.

It is a conglomeration of all these great interests that places London first. When we consider the whole subject it is, indeed, remarkable that in every branch or division of business London is supreme. One might imagine that with the rapid development of the younger nations this great capital of ours might be overtaken and passed in certain departments of human activity, yet such is not the case.

As the years go by, London seems to tighten its grip on the world. It continues to draw toward it all the leading men of the earth. And certainly the long start we have had is a tremendous advantage. In the old days London merchants supplied money for the wars of kings, and as the monarchs realised that they could not conduct their expensive military campaigns without the aid of London, the latter grew in importance, slowly realising the truth that money is the sinews of war. The merchants thereupon gained advantages, privileges, and charters for themselves and their city, and in time built up a great and powerful London. When America came into being London had centuries of work and progress behind it; when France, Germany, Russia, and the other nations were developing London was an ancient city. Spain and Portugal had had their day as the principal dealers in the world's merchandise, but Madrid and Lisbon proved unequal to the strain. They had their chance, maintained a sort of supremacy for a time, but eventually had to give way before the great pioneers of England. How often are we told that London represents an effete civilisation; that it is out of date, that its younger rivals are rapidly overhauling it? These are mere parrot-cries with no justification. The merchants of London, even their very office boys, are the descendants of a long line of workers who form a continuous corporation since the days of King Alfred. The efficiency of London is greater today than ever.

T. VEZEY STRONG



THE HUB OF THE WORLD'S COMMERCE—THE CITY OF LONDON VIEWED FROM ST. PAUL'S

The Divisibility of Matter. Kinetic Theory of Gases. Molecular Forces. Capillarity, Viscosity, and Other Properties.

THE PROPERTIES OF MATTER

In previous chapters we have noted some of the fundamental properties of matter. We have mentioned *extension*, or the property of occupying space; we have also explained the property of inertia. We have also referred to the property which is called *impenetrability*—a rather stupid and misleading name. It does not mean that tea cannot penetrate into a lump of sugar, but simply that where the particles of sugar are the particles of tea cannot also be. This character of matter was also referred to in our second chapter, and we showed how difficult it is to be consistent in our ideas on this point when we come to compare them with the new theory of matter. Only a few years ago it was possible to say that impenetrability is a self-evident property of matter, just as it seems self-evident that matter is that which occupies space, yet both extension and impenetrability, as properties of matter, are now undergoing grave criticism.

Ultimate Divisibility of Matter. Now we must consider another fundamental property of matter, the property of *divisibility*. In considering this property we find ourselves at once in difficulty. In how far is matter divisible? Someone submits to us, let us say, a specimen of pure hydrogen; in theory we divide it and divide it until we reach its ultimate molecules, each of which consists of two atoms of hydrogen. Therefore, in theory, we divide the molecules into atoms, the smallest particles of matter, as we know it, that can exist. But in imagination we can conceive of the possibility of dividing even an atom; and, indeed, we now know that an atom is really a compound body made up of a number of electrons. It is believed that these electrons are absolutely the units of matter. But we have asserted that divisibility is a property of matter; are we not then entitled to declare that even electrons can be divided?

The Problem of the Electron. However small we conceive an electron to be, yet it really has a material existence; we cannot conceive that a sufficiently delicate knife might not chop it in half; yet, as we have already noted, it is more than doubtful whether the existence of the electron is a material existence at all; it is in all probability an electrical existence. In the last resort, therefore, we are compelled to abandon the assertion which has been so long maintained—that divisibility is a fundamental property of matter. We have not really added to our difficulties, however, but have simplified them. On the old view that divisibility is an essential property of matter, we were landed in alternate absurdities. On the one hand, we could not conceive of any particle of matter so small that it could not be divided, and yet if we imagined the process of division to go on for ever and ever, we found ourselves in a difficulty just as great. But it seems to the present writer quite clear that the new theory of matter has disposed of this old conundrum which has puzzled men's minds for centuries. It is true that matter, as we know it, has the property of divisibility, but when we reduce matter to its ultimate units we find that all our ordinary ideas are inapplicable.

Matter Dematerialised. These ultimate units are found not to have any material existence at all, but to be manifestations of energy. Now, it is meaningless to talk of energy occupying space; it is meaningless to talk of energy being impenetrable; and it is still more meaningless to talk of energy being divisible, as if we could take a piece of energy in our hand and cut it in half. When, therefore, we come to study what have long been called the fundamental properties of matter, in the light of the work of the last fifteen—especially the last few—years we find that these so-called fundamental properties are not fundamental, and that we reach a stage in our analysis of matter when they simply cease to have any meaning. We hesitate to use a word which has been employed by spiritualists and all sorts of spiritualistic quacks; but the fact is that, as a French observer has said, modern physics has accomplished the *dematerialisation* of matter, and having revealed it as something which is ultimately not material at all, has compelled us to modify all our old assertions as to what we used to call its fundamental properties.

Molecules. Leaving now these exceedingly difficult and subtle questions, let us now pass on to consider the behaviour of molecules in general, not the behaviour of a molecule of water as distinguished from a molecule of, say, sulphuric acid—that would be more properly a chemical question—but with the behaviour which is common to all molecules, no matter what their chemical composition may be.

Nothing is at Rest. Of the profoundest importance from every point of view—physical, chemical, and philosophical—is the fact that all molecules are in movement. This is a fact upon which all students of the matter are agreed. In our previous chapters we have spoken of molar forces and properties; we have discussed motion and the laws of motion. As these words lie before us on the table they are at rest—the pages will not move unless something moves them; but if we could see the molecules of the pages we would find them to be all in active motion. Consider any mass of matter, such as a billiard-ball, and it may be at rest as a whole or in motion as a whole; these are molar rest and molar motion. But in all the matter

that we know there is no such thing as molecular rest; there is nothing but incessant molecular motion. The molecules that go to make up the ivory of the billiard-ball are in incessant motion among themselves, no matter whether the billiard-ball, as a whole, is moving or at rest. Now, when we have completed our discussion of the properties of matter, we are going to consider the great subject of *heat*, and we shall find that this property, molecular movement, is of the very first importance in relation to the whole subject of heat. No one can possibly understand heat, or the great physical truths to which the study of heat has led us, without having a clear understanding that wherever there is matter there is motion. Indeed, we shall not have proceeded far in our study of heat before we discover that what we call heat is none other than molecular motion.

Molecular Motion of Gases. First of all, let us consider matter in that physical state which we call gaseous. The molecules of a gas are in a state of a much freer and more rapid motion than the molecules of a liquid or a solid. In a previous chapter we have discussed some aspects of the fact called fluid pressure. We have seen that those fluids known as gases always completely fill any space in which they may be enclosed. In this respect they differ profoundly from the fluids called liquids and from solids. It is believed, for the most excellent reasons of many kinds, that the characters of a gas, its pressure, the relation of its pressure to its temperature and its volume (previously described as Boyle's Law), and its behaviour in completely filling any space in which it is enclosed are consequences, one and all, of the molecular movement in the gas. We have to regard the molecules of every gas as rushing violently about in one direction and another, often striking one another or rebounding from the sides of any vessel that encloses them. We must beware, however, of forgetting Newton's law of motion. We must not conceive of the molecules of a gas as changing the direction of their motion at their own sweet will; they have to obey the law of inertia, and their movements and the course of the direction of their movements are determined by forces outside them. If a molecule of a gas moving onward changes the direction of its motion, that is because it has collided with another molecule or with some solid body, such as the side of a vessel, or because some new force has been impressed upon it.

Kinetic Theory of Gases. Now we must look further into this question of molecular motion in a gas. All the facts that physicists have observed have led them to frame what is known as the *kinetic theory of gases*. The kinetic theory of gases asserts that the molecules of a gas are in constant movement, which is of the kind we defined in an earlier chapter as movement of translation—that is to say, not movement of rotation in one place, but movement, as a whole, from one place to another place. This movement of translation implies the possession of kinetic energy by the molecules of the gas; and it is further asserted by this theory that the degree of this kinetic energy depends upon the amount of heat in the gas. Indeed, the amount of heat in the gas *is* the amount of kinetic energy of its molecules. In other words, the heat of the gas and the molecular motion of the gas are one and the same thing. Hence the total quantity of heat in a given mass of gas will consist of the sum of the kinetic energy of all the molecules that are contained in it. Further, the kinetic theory of gases helps us to understand the pressure of any gas or mixture of gases.

The Kinetic Theory and Gaseous Pressure. The pressure of a gas must be regarded as the consequence of the ceaseless bombardment of the surfaces which enclose that gas by its molecules. The pressure of the gas will vary, and indeed does vary, in accordance with this theory. For instance, if we diminish the density of the gas—that is to say, the number of molecules in a given volume of it—we diminish its pressure. This must be so, simply because there are fewer molecules to exercise that bombardment of which we have spoken, and upon which we have asserted the pressure of the gas to depend. Again, the pressure of the gas will diminish if we lower its temperature, and will increase if we raise its temperature. These facts are readily explained by the kinetic theory of gases, for when we lower the temperature of a gas we lessen the amount of heat in it—that is to say, we reduce the amount of molecular motion in it, or the amount of kinetic energy which its molecules possess; the pressure of the gas is reduced because the vigour of the bombardment is less. Similarly, when the temperature of the gas is raised there is more heat in it—that is to say, there is more molecular motion, more kinetic energy, a more vigorous bombardment, and therefore an increase of pressure.

The "Free Path" of a Molecule. Much attention has been paid to the actual speed with which the molecules of a gas move; it varies very widely in the case of different gases. At a temperature of 0° C. the average speed at which the molecules of hydrogen gas move is considerably more than one mile per second. The molecules of oyxgen gas at the same temperature—molecules which, as the student on the course of CHEMISTRY will remember, have a mass 16 times greater than the molecules of hydrogen—have a speed one-fourth of that of the hydrogen molecules.

We have stated that a molecule of hydrogen at the temperature of the freezing point of water would move considerably more than a mile in one second; but we must remember that it is surrounded by a host of other molecules with which it must often collide. Hence there arises this very interesting question: In any given gas, at any given temperature and pressure, what is the average actual distance through which a molecule can move before it strikes against another molecule and has its course changed? This average, or mean distance, is technically known as the *mean free path* of a molecule. Plainly, the more dense the gas be—that is to say, the more

its molecules be crowded together—the shorter is the distance which the molecule can expect to travel in a straight line without, so to speak, bumping up against another molecule. Now, it is stated that in the case of the molecules that go to form the gases of the air within the ordinary limits of the atmospheric pressure and temperature, the mean free path must be exceedingly short, amounting to perhaps about 1000 times the incredibly minute diameter of a molecule. The number of collisions which any molecule must undergo in a second under such conditions must be almost immeasurable. If, however, we consider the molecules of the gases of the air that are present in the so-called vacuum of an ordinary incandescent electric lamp, we find that the proportion of molecules to the space they occupy is so small that, were it not for striking against the glass itself, each molecule would have a mean free path of more than 30 ft.

No Cohesion in Gases. Now let us consider the physical state of a gas and contrast it with the physical state of liquids and solids. If we move one end of a stick, the other end moves also—a most remarkable and wonderful fact, though it is such a common case that few of us have ever thought about it. But when we do come to think about it we see that there must be some intimate relation between the molecules of the stick, so that when one end of the stick is touched something is transmitted which compels the other end of the stick to move also.

This property of the molecules of the stick we will call cohesion, and the first point to note about the physical state of any gas is that its molecules have no cohesion. They are absolutely independent of one another save for the fact that they are apt to interfere with one another by means of collisions ; but it is evident that of cohesion—as the molecules of the stick have cohesion—they possess not a trace. In fact, then, the physical state of a gas, as compared with the physical state of a liquid or solid, is relatively simple. We have merely to conceive of the gas as consisting of a number of independent molecules, each possessed of energy of motion, or kinetic energy, in virtue of which it flies onward in a straight line until it strikes something which sets it on a new course in another straight line, and so on indefinitely. There is no cohesion between the molecules; and though we must believe that gravitation acts between them, there is no *molecular attraction.*

Molecular Motion of Liquids. Let us turn to consider the case of a liquid and the peculiarities of its physical state. Here, again, we may be absolutely certain that there is abundant molecular motion, and we must inquire into the differences between molecular motion in the case of a liquid and the case of a gas. But first of all let us notice a most important consideration, which will reappear when we come to consider the contrast between a liquid and a solid.

We are accustomed to speak and think as if there were three states of matter—solid, liquid, and gaseous—the distinctions between them being absolute. But, of course, we cannot forget the fact that there are many solids, such as pitch, which pass by continuous stages from the solid to the liquid state. This, and many similar facts, together with our philosophical belief that Nature is not broken but continuous, and together with the conceptions which we must form as to what happens during the gradual process of evaporation of a liquid, or liquefaction of a gas or solidification of a liquid—all these considerations lead us to the very important conclusion that the transitions of ice, for instance, to the state of liquid water, and then to the state of water vapour, are absolutely continuous.

Transition from Solid to Gaseous. We are compelled to believe that all the stages between the solid and the gaseous state, which our reason compels us to assume, do really exist. The fact merely is that, as a rule, certain of these stages, such as the stages between ice and liquid water, are so rapidly passed through that unless very careful experiments are made for the purpose we fail to observe them. But the new science of physical chemistry has devoted much attention to this subject; and as the years go on we constantly become more and more certain that the so-called three states of matter represent not states that are absolutely distinct from one another, but states which are continuously connected by an unbroken series of gradations, certain of which happen to be very inconspicuous or so rapidly passed through that in the case of the majority of substances and under ordinary conditions we fail to observe them.

The Liquefaction of Water Vapour. Having insisted on this most important point, let us see what happens when a gas is liquefied. Let us consider the most familiar instance, which is that of water vapour or gaseous water. The use of the words gas and vapour is merely a matter of somewhat doubtful convenience, the word gas being applied to substances which are most familiar to us in the gaseous state, and the word vapour to substances in gaseous form which, however, are most familiar to us either

EXAMPLES OF THE CRYSTALS OF WATER SOLIDIFIED INTO THE FORM OF SNOW

as liquids or as solids. If, then, we consider the case of water vapour, we may ask what must happen when a given mass of water vapour is subjected to an increasing pressure? We will assume that the temperature remains the same, else our problem is complicated. As the water vapour is compressed, its molecules become crowded more and more together, until at last we may imagine that a point is reached when a certain number of molecules would become so crowded that the force called molecular attraction would be able to assert itself between them and their neighbours. The excellent illustration has been given of the case of some planet or comet conceived to be wandering through space in a free path. By chance it comes within a certain distance of some other body, such as the sun, and gravitational attraction asserts itself to such an extent that the wanderer loses its freedom of movement and is compelled to enter into a special relation with the attracting body—such, for instance, as the relation which the earth holds to the sun as she travels round him. Now, something like that happens when the water vapour we are considering is compressed beyond a certain point.

Molecular Attraction. In the case of a molecule here and a molecule there, and gradually in the case of more and more molecules, the force of molecular attraction, whatever that really may be, comes to assert itself, and a new state of affairs is gradually set up, in which the water vapour gradually loses the character of a gas and assumes the character of a liquid. We must thus believe that the molecules of a liquid have become entangled with each other in the same sense as the earth is entangled with the sun.

Previously they were able to move in any direction, and had so much kinetic energy of their own that they could even fly upward, notwithstanding the force of the earth's attraction. But now they have lost their momentum and have established a new relation with each other. Gradually the process of liquefaction continues, in accordance with the assertion we have already made that the transition from the gaseous to the liquid state is gradual and continuous. When the total volume of water vapour has been sufficiently reduced, we find that it is no longer water vapour, but liquid water.

A Possible Electrical Phenomenon. Exactly the same results as have been achieved by increasing the pressure without alteration of the temperature would also have been achieved by reducing the temperature—that is to say, by reducing the amount of kinetic energy in the molecules—even though we had not subjected the water vapour to any increase of pressure.

How, then, are we to conceive the physical state of a liquid, and what is the nature of the motion of its molecules? They are no longer moving in *free* paths, long or short; the force of molecular attraction has been asserted, and the molecules are probably moving in complicated orbits round each other at a speed which, though very great, is less than the speed at which they formerly moved when enjoying the complete mutual independence possessed by the molecules of a gas. Well indeed it would be if we could now explain the exact nature of this force which we call molecular attraction. Ultimately, no doubt, it will be shown to be an electrical phenomenon, but that time is not yet.

The Process of Freezing. Precisely the same change of conditions as turned the water vapour into liquid water will, if made more marked, yield us ice in its place. The essential difference between the solid and the liquid states is that the solid is possessed of less molecular motion than the liquid, so that the forces of molecular attraction are enabled still further to assert themselves. Let us turn to the illustration from astronomy. What would happen at this moment if the kinetic energy of the earth in its orbit was reduced or completely removed? In the first instance gradually, by a sort of narrowing spiral, and in the second instance immediately, by motion in a straight line, it would fall into the sun. A process exactly parallel to this is what happens where, by abstracting heat from liquid water—heat being none other than a form of kinetic energy—we reduce the kinetic energy of its molecules to such an extent that molecular attraction asserts itself still further, and their orbital motion around one another ceases. The consequence will be that the molecules come closely together, so closely that they cohere; and if we move one end of the block of ice that is formed, the other end, in virtue of this cohesion, will move also.

Molecular Motion of Solids. Are we to regard the motion of the molecules in the solid so formed as having ceased? Most assuredly not. Though the kinetic energy of the molecules has been so much reduced that they can neither fly about independently of each other as in a gas, nor yet revolve in orbits round each other as in a liquid, yet some kinetic energy still remains to them. Much heat has been abstracted from the water, but by no means all. There are many colder things than ice, and all ice is not at the same temperature. Probably we must regard the molecular motion of such a solid as ice as consisting of a to-and-fro or vibratory motion of pairs or groups of molecules. Pray observe the use of the word groups. For consider what is really the physical state of ice, which consists of crystals. These crystals must consist, in their turn, of regularly arranged groups of molecules, harmoniously vibrating with one another. The precise manner of their vibration will determine, we must suppose, the shape and size and other characters of the crystals of ice or any other substance.

The Result of Solidification. It is scarcely necessary again to insist that, as in the previous case, the process of solidification is a gradual one—first one molecule and then another being so far deprived of its kinetic energy, as heat is abstracted from the mass, that it can no longer maintain its orbital motion. But suppose that the process has been completed and that the whole mass is now solid, and

suppose that we continue the process of reducing the temperature, and thus remove still more energy of motion or kinetic energy from the molecules of the ice. The result will be that their vibrations or to-and-fro movements will become less extensive, and the ice will shrink or contract. It is the general rule that when a body is heated it expands, and that when it is cooled it contracts. These facts can readily be explained on the theory of molecular motion: as heat, kinetic energy, motion, continues to be removed from the ice, it continues to shrink more and more, thus showing that its volume—the very space it occupies—is determined, partly at any rate, by the motion of its molecules. What will happen next?

The Coldest Cold. This is a fascinating and most important question. Suppose that we go on abstracting heat or molecular motion from any body, we must ultimately reach a point when there is no more heat or molecular motion in it—that is to say, when its molecular motion has been absolutely abolished. Such a body, and such a body only, would be absolutely cold, being destitute of all heat or molecular motion. But the study of this great question must be deferred for the present, until we have made a further study of the facts of heat. For the moment it will serve, perhaps, to keep alive the reader's interest in this subject if we say that the absolute zero of temperature has never yet been reached by anyone, and that it seems more than probable that the attempt to reduce any substance, even frozen hydrogen, to this ultimate depth of cold must for ever fail. As to the aspects which matter would present if deprived of all its molecular motion no one will dare positively to say; but this we consider at a later stage.

Molecular Forces in Detail. Perhaps the reader may be apt to think that molecular forces, because they are displayed in exceedingly small bodies, can have no very great magnitude. But that would be a very great mistake. Let him consider, for instance, the strain to which steel is exposed in many of its industrial applications; let him consider the number of tons which a steel wire will support—yet what is it but molecular attraction that keeps together the molecules of steel, even though such a tremendous strain is put upon them, endeavouring to pull them apart? We must clearly understand that though molecular forces act only at very minute distances, yet within those distances their power is gigantic. Gravitation, which we so constantly think of as tremendously powerful, is almost a negligible quantity when it is pitted against molecular attraction. When a great weight is supported by a steel wire it is evident that, if we consider any level in that wire, the molecular forces of that level are sufficient to more than counteract the weight—that is to say, the expression of gravitation—of all the mass of wire below that level and of the body that hangs at the end of it. We have chosen solids for our illustrations because it is in them that the molecular forces are so powerful, but the molecular forces are very far from being negligible in many liquids.

Surface Tension. Every reader is familiar with the fact that a tumbler may be filled with water so full that the surface of the water is visible higher than the edge of the tumbler, yet the water does not run over; though, if the finger be applied to the edge of the tumbler and the *surface* of the water be thus broken, some of it will run over the edge of the glass at the point where the finger was applied. This fact is a familiar illustration of the result of molecular attraction as it exists at the surface of a liquid. The technical name for it is *surface tension*, and its power may be measured by measuring the force which can be applied in such a way as to cut the surface of a liquid, but which, in virtue of surface tension, fails to do so. A thoroughly well greased needle, very gently placed on a still surface of water, will form a groove for itself, and lie on it without sinking. Now, how are we to explain this fact of surface tension? Why does the surface of the liquid look as though it were covered with an elastic skin made of the same stuff as itself?

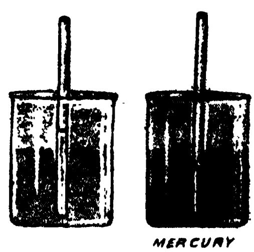
The surface of the liquid is composed of a number of molecules, and these have the mutual relations which we have already described. Immediately above the free surface of the liquids, as in the case of the filled tumbler, there are innumerable molecules that constitute the various gases of the air.

Formation of Drops. Now, if we consider any molecule of the liquid, we see that it is attached by, and held to, the other molecules that are around and below it, whereas, on the other hand, it is not at all attracted—or, at any rate, not in anything like the same degree—by the gaseous molecules that are above it. This fact of surface tension explains not only the curved surface of water in a full tumbler, but also, for instance, the fact that when water slowly falls it does so in drops. The formation of these drops and their curved external surface depend upon the fact that all the molecules of the liquid are, so to speak, bound to one another, while no force from outside tends to counterbalance their mutual attractions. Hence the surface of the liquid takes the shape which has the smallest possible area. Gravitation to some extent complicates the matter, so that often the drop is not completely spherical, but bulges a little at its lowest point. This familiar fact of surface tension has its uses, for upon it depends the process of making shot, which is accomplished by allowing a quantity of molten lead to fall through a sieve from a height into water. Gravitation in this case is negligible, and as the drops of lead fall and cool they solidify in the spherical shape which is imposed upon them by surface tension.

Capillarity. This word is derived from the Latin name for a hair, and is applied to the facts which are observed when liquids are placed in very hair-like or slender tubes. As every one has noticed, if such a tube be dipped into water, the water will rise some distance in it. The

case is exactly similar with tea, which will run up into a lump of sugar. Furthermore, the surface of the water in the tube will be curved concave upward. If, now, a similar tube be dipped into mercury, the mercury within the tube will actually stand at a lower level than that outside it, and the surface of the mercury in the tube will be convex upward. These facts are all entirely dependent upon the same molecular attraction that we have already called surface tension. This fact of capillarity is of great importance to the botanist, who finds in it a factor which helps to determine the rise of the sap in a tree—a process which, in some measure, corresponds to the circulation of the blood in an animal.

Viscosity and Compressibility. *Viscosity* is a property possessed in varying measure by all fluids, both liquids and gases. In consideration of the physics of fluids, the fact of their viscosity has to be ignored owing to the complications which it introduces; and so we have to imagine what physicists call a *perfect fluid,* which has no viscosity—that is to say, one which in passing over any surface exercises no force upon it except that force at right angles which we described under *fluid pressure.* That fluids vary in their viscosity everyone knows who has compared methylated spirits with treacle; both are fluids, yet how profoundly different is their physical state! *Compressibility* is another occasional property of matter, the word being used to describe the fact that when matter, liquid, gaseous, or solid, is subject to pressure its volume is reduced, or may be reduced. Reference has already been made to the contrast between liquids and gases in this respect, the former having for long been regarded as incompressible. We cannot now accept, however, the old division of fluids into *compressible fluids* and *incompressible fluids,* names formerly applied to gases and liquids, as it is now known that liquids are not incompressible. When we come to look into this property of matter, it is evident that it must depend upon a lack of continuity in the structure of matter—that is to say, if all the space occupied by a given volume of any kind of matter, looked at as a whole, were really filled everywhere by the minute particles constituting the mass, the mass would necessarily be incompressible. Hence we must conclude that the compressibility of matter depends upon its discontinuous structure; it is better not to say that it depends upon its porosity, for that term is better confined to describe the character of bodies, either liquids or solids, whose behaviour is such that their structure must be conceived as containing numberless pores or apertures or interstices, into which other matter from without can enter.



EXAMPLES OF CAPILLARITY

Cohesion of Matter. *Cohesion* is another property of matter to which considerable reference has already been made. It is not worth while to draw any distinction such as has been drawn between cohesion and adhesion. In considering surface tension, we are really considering a consequence of the same force as that which, when displayed in the interior of a body, is called cohesion, and this is, again, in reality the same force as that which is called adhesion, and is displayed between smoothly fitting surfaces of two bodies, such as metal plates when these are pressed closely together so as to squeeze out the air from between them.

Hardness. *Hardness* is another property of solid matter, and is usually expressed by means of a scale that indicates, in order, a number of substances so arranged that the first can be scratched by the second, the second by the third, and so forth, but not *vice versâ.* Hardness is not merely a matter of density of a substance, nor does it depend merely upon its chemical composition; unquestionably it depends upon molecular forces, and it is worth noting that it is often associated with *brittleness.* The scale of hardness invented by Von Mohs is as follows.

1. Talc. This can be cut by the thumb-nail.
2. Rock-salt, or selenite.
3. Calc-spar, or Iceland spar.
4. Fluor-spar. This can be cut by a steel knife.
5. Apatite, or asparagus stone. This can be scratched by a knife.
6. Fel-spar—its purity being essential. This can be scratched only by the hardest steel.
7. Rock crystal, or quartz. This is able to scratch glass or an ordinary steel knife.
8. Topaz.
9. Sapphire.
10. Diamond, which is able to cut glass.

Rigidity and Elasticity. *Rigidity* is another property of matter which enables a body to resist tendencies towards change of form. *Elasticity* is another property of many bodies. The essential part of our conception of elasticity is that an elastic body is able to return to its original bulk and shape after the application of a force. We must remember that elasticity may be expressed in two opposite ways. A gas or a ball of indiarubber is elastic because it springs back again to its original bulk after it has been compressed, while a piece of indiarubber is similarly elastic in that it returns to its former length after it has been extended. This property of elasticity is extremely important in a higher realm than that with which physics mainly deals, for it is one of the most important properties possessed by muscular tissue. The greater part of the act of expiration is mechanically accomplished, without any nervous or muscular effort of ours, by means of the elasticity of the muscles of inspiration, aided by the elasticity of the ribs.

Plasticity. The opposite property of elasticity is *plasticity.* The art of moulding in clay is called plastic art—wet clay being a substance which has no elasticity worth mentioning,

and which is, therefore, perfectly suited for the purpose of the modeller. Every solid has a limit of elasticity, and if strained beyond that limit undergoes such a molecular change as to make it plastic.

Ductility. *Ductility* is a property of many metals, in virtue of which they can be drawn into wire. We may contrast, for instance, iron wire, which is so familiar, with the results that are reached when one makes a wire of lead, the most plastic and least ductile of metals. It might be thought that the same metals which can readily be extended in the form of wire would be capable of being extended in the form of flat plates; this property is known as *malleability* (Latin *malleus*, a hammer). But, as a matter of fact, lead is exceedingly malleable, and can be hammered out to very considerable thinness, though it can scarcely be drawn out into wire at all. The property upon which ductility, as distinguished from malleability, depends is called *tenacity*, and is possessed in the highest degree by the best steel. Very few people have any idea of the extraordinary tension, or longitudinal stress, which is borne by the steel wires of a good piano.

Even though we are totally unable to explain these various properties of various substances in terms of molecular forces, we are, at any rate, able to show that some of them vary with varying temperatures, as we would expect them to vary if the theories already stated as to the relations between heat and molecular energy were true. According to these theories, for instance, the process of adding heat to a solid body must imply an increase of its molecular motion in the direction of the state which obtains in the case of gas. Hence, we are not surprised to find that the heating of a solid reduces its cohesion.

Diffusion. The last property of any kind of matter which we need to consider here is the property of *diffusion* which is possessed by gases, and which becomes quite intelligible if we recall what has already been said regarding the molecular motion in a gas, and what we have now learnt to know as the kinetic theory of gases. Recalling the conceptions already noted, let us consider what will be liable to happen if two different gases be poured into a vessel one above the other; there is no surface tension in this case. Does it not seem inevitable that at what is called the interface, or the level where the two gases meet one another, there will be a very marked tendency to intermixture? Such intermixture indeed occurs, and is known as *diffusion*. The rate of diffusion is found to follow an absolute law, and is strictly consistent with—indeed, is the strongest proof of—the kinetic theory. Diffusion occurs in all fluids, not merely in gases, though the diffusion of liquids, as one might expect, is much less rapid, and is complicated by the facts of surface tension. For instance, oil and water do not diffuse into one another; that is to say, they do not "mix." The relative weight of liquids also affects their mutual diffusion.

The New Theory of Matter. Already we have rejected the idea that the units of matter are hard things, like "foundation stones." Further, we have carefully distinguished between mass and weight, and have noted that weight is, so to speak, accidental, and that mass is perhaps the prime character of matter. We have seen, too, that it is the property of inertia from which our notion of mass is derived; but we also found that, according to the most recent investigations, the inertia of matter must be looked upon as electrical inertia, and matter itself as an electrical phenomenon. The final conclusion to which we came was that matter is merely a particular form of energy. We noted also that the belief in the conservation or the eternal persistence of matter—quite recently held by the chemist—can no longer be maintained in the light of these facts which are now rapidly being discovered of the disintegration—if not, indeed, apparent annihilation—of matter under certain conditions.

The Meaning of the Word Energy. Now, before we pass to the greatest fact of physics, which is the doctrine of the conservation of *energy*, it is highly necessary to clear up once and for all our ideas as to the proper use of this word. Energy, in the philosophical and scientific use of that word, does not mean possibility for action or capability for work; it implies an idea much more profound and important than any which those words convey.

Neither in the original use of the word by Dr. Thomas Young, who introduced it, nor in its use by any of the great makers of physics since his day, does the word energy describe an attribute of matter. The importance of gaining as clear a notion as the human mind will permit of the real nature of energy lies first of all in the fact that the new theory of matter, which is reducing matter to something like its proper importance, necessarily directs more and more attention to that of which matter, as we are now beginning to see, is but a temporary manifestation; and, secondly, in the fact that, by a sort of poetic justice, we find the latest developments of physics completely to have destroyed that preposterous doctrine of materialism which, so popular forty years ago, was based upon physical conceptions that sound simply mediæval to modern students of the subject.

In modern scientific thinking the word energy is used to describe the *something*, the *power* which is really the underlying and essential fact of all facts and all phenomena, except the facts and phenomena of mind.

An Unsatisfactory Definition. Certainly such a definition cannot satisfy the physicist, nor is there any physicist who is perfectly satisfied with any conception that he can form of the nature of electricity—obviously necessary to an understanding of the electrical phenomenon which we call matter. But though the new theory of matter is at present so unsatisfying from the point of view of exact hard-and-fast science, yet it is already able to perform an incalculable service for philosophy.

C. W. SALEEBY

Yard and Special Drainage Systems and Materials. Water and Road Gullies. The Work of the Drainlayer.

DRAINAGE APPLIED TO BUILDING

Objects of Drainage. The objects to be arrived at in a modern system of drainage as applied to individual buildings are (1) to convey away the sewage without any risk of contaminating the land through which the drain is carried; (2) to ensure that the whole system is one that shall be self-cleansing and shall be effective even under the conditions of complete want of attention which usually prevail; (3) to provide means of ascertaining readily the causes of any interference with the regular working of the system and for promptly dealing with such interference; (4) to provide against the possibility of introducing into the building by means of the system of drainage the poisonous gas generated in the sewers and cesspools, and even to some extent within the system itself.

These are the most important requirements which must be borne in mind in dealing with a system of drainage, and to provide for meeting them. not only good design, but the best materials and workmanship are essential. The tests applied to a drainage system are properly severe. The work is almost entirely buried out of sight, and in most cases, unless a defect shows itself, it receives no attention from year's end to year's end, and it is therefore of the highest importance to secure conditions that shall be as good as possible.

The drains of an ordinary building consist of a series of tubes through which the matter to be conveyed flows until it is discharged into a public sewer or cesspool, or is distributed over land or otherwise dealt with. [For treatment of sewage, see CIVIL ENGINEERING.]

System and Materials. There is often a double system of such tubes, one of which is reserved for water which is clean and practically free from solid matter or contamination, and usually consists principally of the rain-water collected from the roofs of any building; these are described as *rain-water drains.* The other receives all foul water, including the discharges from water-closets, urinals, sinks of all kinds, and bath and lavatory wastes, all of which contain putrescible matter and are liable to rapid decomposition and to generate a gas known as *sewer gas,* highly injurious to health. These are generally classed as *soil drains,* a term more particularly applied to those conveying discharges from water-closets. The circumstances of various buildings differ widely, but whether an isolated country house or a town building is to be dealt with, certain principles must be observed, and the actual methods of construction are to a large extent identical.

The materials used in the laying of a drainage system are to a considerable extent ordinary building materials. The preparation and laying of concrete has been already dealt with. Certain work in bricklaying must be referred to, but for fuller explanations of the bricklayer's work see BRICKLAYING. The materials now to be considered are those employed in the actual formation of the drains—*pipes, channels, bends, traps* of various forms. [For the construction of large sewers and conduits, see CIVIL ENGINEERING.]

Pipes. These must be straight, true in section, absolutely impervious to water, not easily liable to fracture, and of material that will not be affected by the acids contained in the sewage, and the inner surface must be perfectly smooth and offer no obstruction to the flow of its contents. It is desirable that the diameter of the pipe should be as small as possible, provided it is adequate to the maximum flow, so that at periods of minimum flow the depth of water in the pipe compared with the area of that part of the invert covered by it, described as the wetted perimeter, should be as large as possible. The materials used for such pipes are *glazed stoneware, glazed earthenware,* and *glazed terra cotta* and *cast iron.* The various forms of earthenware pipes referred to are all similar in form [for manufacture, see POTTERY], and are almost always salt glazed. They are usually about 2 ft. long [16]. One end is formed with a socket to receive the other, or *spigot* end. of the next pipe. The outer surface of the spigot and the inner surface of the socket have, as a rule, fine annular channels formed on them, their purpose being to assist the adhesion of the cement.

The internal surface must be thoroughly glazed. and free from all excrescences and roughness which would check the flow of sewage, and pipes should be inspected to ensure this. A slight roughness or projection in one spot need not necessarily lead to condemning a pipe, but care must be taken to see in laying that such defect is placed not in the invert, but at the top of the drain. Such pipes are made of various diameters, from 3 in. upwards. The thickness of the material in stoneware pipes is usually $\frac{9}{16}$ in. for 4 in. pipes, $\frac{11}{16}$ in. for 6 in. pipes, and beyond this size $\frac{1}{12}$ of the diameter. There are some variations from the general type. *Taper pipes* are formed which are regularly reduced in diameter from one end to the other [20], and may have the socket formed on either the large or the small end. *Cleansing pipes* [21] are employed for building into manholes that are not fitted with traps, but have a kind of hood-shaped enlargement formed at one end, increasing the vertical but not the horizontal diameter to facilitate the introduction of cleaning rods.

A rougher class of pipe is used for land drainage, where the important consideration is the collection and removal of water which percolates through the ground, and which is not contaminated with sewage.

These are known as *agricultural drain-pipes*, and are short tubes from 2 in. to 6 in. in diameter, formed of burnt earthenware, without sockets, and unglazed. They are laid end to end, and are not jointed. Their purpose is to give free passage to the water collecting in the trench in which they are placed, and which can enter the pipe at any joint. They are sometimes used for passing water collected by embankments through the base of the wall to the front, and for this purpose are embedded in the concrete or masonry, and are known as *weeping pipes*.

Bends. These are pipes so formed as to change the direction of the axis of the pipe. They are made to a great variety of curves, from a quadrant [22] to a very flat bend. They should not be used in soil drains, but may, if necessary, be used in rain-water drains.

Junctions. Various forms of these are manufactured. They may be Y-*junction*, single, or double [23], and they may be arranged so that the inlet joins the main pipe at various angles; but it is undesirable that the angle between the axis of the two drains should exceed about 45°, and right-angled junctions are not tolerated,* as nothing is more apt to produce an obstruction in the drain. Junctions are often made between pipes of different size—*e.g.*, one of 4 in. diameter may join one of 6 in. Junctions, like bends, should only be employed for rain-water drains, and not for soil drains.

Channels. These are open pipes [24]; usually semi-circular, and with half-sockets. They are used sometimes for the conveyance of surface water at the ground level: in a drainage system their special use is to enable junctions to be made between various soil drains. The manner of using them will be more fully described in connection with the construction of *manholes*.

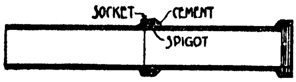
Taper channels are formed in a manner similar to taper pipes. *Bends* are also formed in channels [22], and for some forms of bend the section, instead of being semi-circular, is a full three-quarter circle [24]. There is a much greater variety in the form of *channel bends* than of pipe bends, as in some cases it is necessary in forming manholes to bring in a branch drain from a direction that will require the flow of the contents to be almost reversed in the manhole [20], and it is mainly in the case of such bends that three-quarter channels are required, the outer side of the bend being covered in to retain the flow of water in the channel, which without such protection would tend from its own velocity to overflow it, and deposit any solids on the sides of the manhole. For this extreme case, bends of a great variety of radius and of different lengths may be procured to fit almost any angle at which a drain can be received, a slight adjustment being always possible. The upper end of any channel is provided with a socket, and is at right angles to the axis at this point, but the lower end is splayed so as to be parallel to the axis of the central channel where it is employed to form a junction.

Traps. These are devices to prevent the return of the sewer gas from the sewer to the building. The earliest [25] form consisted of a small chamber in the line of the drain sunk below its general level, with a *diaphragm* fixed across it extending from the top of the chamber to below the level at which the water would stand in it. A barrier is thus interposed, closing the upper part of the chamber and the drain above it against any return of an air current, while not preventing the flow of the sewage underneath the diaphragm. This was known as a *dip trap*. If well constructed, it was efficient so far as its special purpose was concerned, but had various drawbacks—it checked the flow of the sewage, and solids were apt to be deposited in the chamber and block it, and it was not easy to make, and keep it, air-tight. Such traps are no longer used, but the principle of the dip trap is employed in all forms of traps, the essential feature being the interposition of a barrier in the course of the pipe that will, under ordinary conditions, prevent the return of air up the pipe. Such traps, however, are now formed of the same material as the pipes, and though some of them are made in more than one piece, the portions containing the barrier between the outlet and the basin, in which water always stands, are of a single piece.

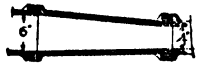
The barrier is formed in various ways in different traps, but always extends below the level at which water stands in the trap; the bottom of the outlet is arranged at a higher level than the bottom of the barrier. The pipe is thus actually closed or sealed by the body of water always standing in it against the upward passage of air or gases, while allowing water or sewage to flow through it. The depth to which this barrier penetrates below the surface of the standing water is referred to as the *depth of the water seal*.

Modern Forms of Trap. The modern forms of intercepting trap [28] are made by introducing into the length of the pipe a bend of such a character that the upper part of the pipe dips below the water-level forming the seal, while the lower part of the pipe forms a basin to retain the liquid. The lower end is formed with an ordinary spigot to join the drain below; the upper end has a half-socket to receive the channel. The upper half above the seal usually dips sharply; the lower, or outlet half has a more gradual rise, the object being to interpose as little check to the flow of the sewage as possible; and where the conditions of the drainage system permit, the upper side may have a cascade formed by keeping the inlet at a higher level than the outlet, so that the flow is discharged into it with a slight impetus.

The form of the trap makes it impossible to introduce a cleaning rod through the trap itself, and an upper arm is provided for this purpose. This is carefully closed when not in use, or the utility of the trap would be destroyed; but the stopper closing it may be attached by a chain

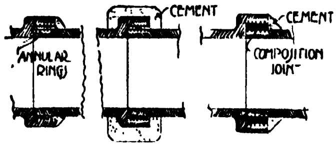


16. Drain-pipes



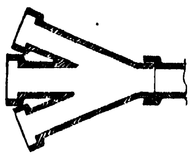
20. Diminishing, or taper pipe

22. Section through a pipe bend, or plan of a channel bend

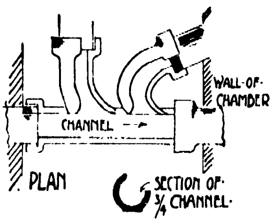


17. **18.** **19.** Stanford's joint
Forms of cement joints

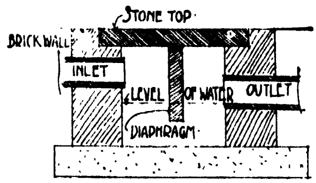
21. Cleansing pipe



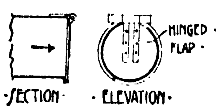
23. Double junction



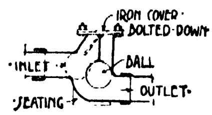
24. Method of using channel and channel bends



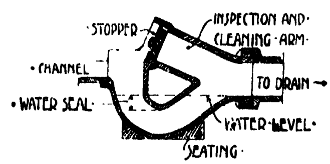
25. Old form of dip trap



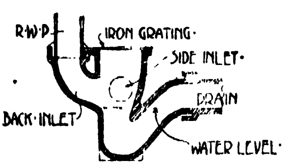
26. Outfall flap



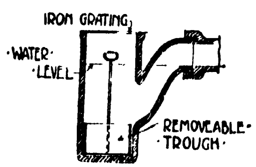
27. Ball trap



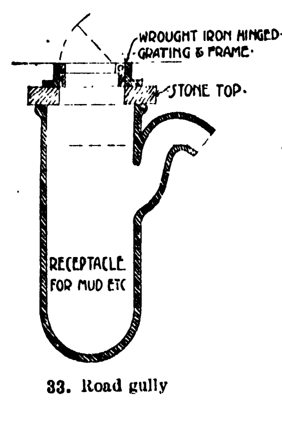
28. Intercepting trap



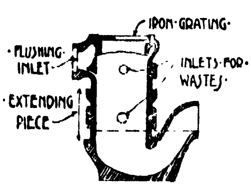
29. Waste-water gully



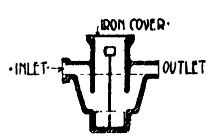
30. Surface water, or yard gully



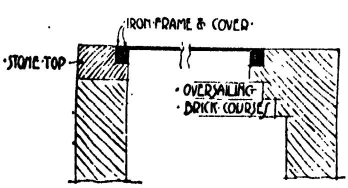
33. Road gully



31. Grease trap, with extending piece and flushing rim

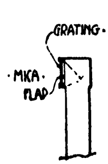


32. Grease trap, with tray



35. Upper part of a manhole

With stone top and cover | **With brick over-sailing courses and cover**



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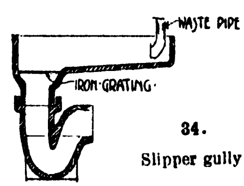
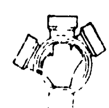
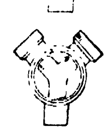


34. Slipper gully



37.



38.

Stoneware junction and inspection chamber

SECTIONS OF DRAIN-PIPES AND FITTINGS

to the upper part of the manhole, so that, should the trap become stopped and the manhole filled with sewerage or water, the plug may be withdrawn and the chamber emptied.

Such an intercepting trap is used in a drainage system at or near its termination, before it enters the sewer or cesspool, to intercept the return of sewer gas. Various makers manufacture them in a variety of forms, but the essential as described above should be found in all of them.

The Problem of Back Flow. It happens occasionally that a drain is subject to a back flow of water or sewage from the sewer. This may arise when the outlet discharges into a tidal river at times of exceptional tides, or, in the case of a sewer being of inadequate size, on the occasion of exceptionally heavy rain. This is not easily dealt with; no form of check that does not act automatically is of any great value in most cases.

Flaps are sometimes placed at the outfall of a drain [26], which, on any back pressure arising, should close the outlet till such pressure is removed; but this must be applied in the sewer, and in small sewers it cannot always be adopted. A form of trap designed to meet such cases is the *ball trap* [27]. This is provided with a hollow metal ball that, under ordinary circumstances, leaves the orifice free, but if any back pressure arises is lifted by the returning water and is pressed against and closes the orifice. This device is open to the objection that the orifice, or the ball, may become somewhat foul from the sewage, and may not close properly, but it has been found efficient in many cases. The ball is sometimes hung with a hinged joint from the top, and in some cases is loose, the trap being designed so as to guide it into position when floated.

Gullies. Traps are required in many other situations, and take various forms. Those termed *gullies* are intended to receive the discharge from sinks and rain-water pipes, yards, paths, &c., and are open to the air at the top. Their object is to prevent any pipe which is connected with the inside of the building, or the top of which terminates near a window, from having a direct connection with the drains. The discharge may take place above a grating placed at the top of the gully [29], but this grating may get stopped through the deposits of solids in the discharge itself, or through an accumulation of leaves, or to some accidental circumstance, and the discharge will then not enter the drain, but overflow around it and soak into the ground. Pipes should therefore discharge into a gully below the level of the grating, a small pit being formed, if necessary, for this purpose and covered with a grating. For many pipes a good method is to connect the ends directly to inlets provided at the back or sides of the body of the gully.

Some makers provide gullies with extending pieces [31], so that the gully may be sunk to any required level below the ground. Such pieces may each have one or more inlets provided, so that the gully may receive the discharge from several pipes. Gullies which are formed of two or more pieces must be jointed. The upper part is adjustable to the pipe, the lower part to the drain.

Yard Gullies and Surface Water Gullies [30]. These differ from the ordinary gully in the manner of forming the seal and in the form of the bottom; this is made deep, and the outlet is kept near the top so that the body forms a catch pit which will retain any sand, gravel, or other solid material washed into it during heavy rain, and prevent it from passing into the drainage system. Such gullies are often provided with metal receivers fitted with a handle; these are placed in the bottom and receive any solids, and can be lifted bodily out, emptied, and replaced. The lower part of the gully may be made deep and of considerable capacity, and the water seal should also be deep, as in dry weather such gullies are very liable to lose the water which forms the seal by evaporation.

The Road Gully [33]. This is a variation of the form of gully last described, and has a very large body or container sunk deeply below the trapped outlet, and capable of holding a considerable bulk of material washed from the road surface. These are usually emptied periodically by means of long-handled scoops.

The use to which scullery sinks are put results in the discharge of a great deal of greasy matter into the drains. When this leaves the sink it is often quite hot, but on being discharged into the water standing in a trap it becomes chilled, the grease congeals, and is very liable to foul the drain which carries it off, adhering to the sides and decomposing. To meet this difficulty *grease traps* are provided.

Grease Traps. The object of these is to retain the greasy matter in the trap till it has congealed. To achieve this the body of the trap is made large, so that a considerable bulk of water is retained in the trap and is always cool or cold. The outlet is considerably below the surface. The grease, on entering the trap, rises and collects on the surface, and there congeals.

There are two methods of disposing of this congealed grease. The first is to provide a form of tray that can be lifted out, bringing out the grease, which must be burnt or otherwise disposed of [32]. There is, however, a great probability that the duty of regularly cleansing out such a trap will be neglected. The more satisfactory method is to supply a trap provided with a flushing rim [31], such as is found in the pan of a water-closet, and to connect this with a tank which discharges automatically at fixed periods a considerable body of water into the trap through the rim, and which completely flushes out the trap, breaks up the congealed grease, and carries the whole through the drain with the flush of water. The amount of water used each time is determined by the size of the cistern, and depends upon the use which is made of the trap. The frequency of the discharge is capable of regulation.

R. ELSEY SMITH

The Defences of Seed Plants Against Weather and Members of the Animal Kingdom. How Ants aid Flowers.

HOW PLANTS PROTECT THEMSELVES

Enough has already been said about the way in which drought-plants (*xerophytes*) tide over the unfavourable season of the year, and this must serve as a partial illustration.

The numerous cases where plants possess spines, thorns, and prickles are partly at least to be interpreted as adaptations whereby defence against many vegetarian enemies is more or less attained. In the sloe (*Prunus spinosa*), for example, the spines are modified branches [142]; in gorse (*Ulex Europæus*) they are branches and leaves; and in cacti the green parts are thickened stems and the spines reduced leaves; while in holly (*Ilex aquifolium*) the prickly leaves answer the purpose of spines. The stinging hairs of the nettle [145] which exude an irritating acid when touched are a familiar example of protection against vegetarian animals.

The Primary Use of Liquid Rubber. The grubs of many beetles live in wood, upon which they feed. This probably gives a clue to the primary use of the important commercial substances indiarubber and guttapercha, which are the dried sticky juices of various shrubs and trees living in hot climates. Beetles of the wood-boring kind, which seek to pierce and lay eggs in such plants, are liable to be snared and killed by the viscid fluids which ooze out.

Arums, and various other plants, ward off the attacks of snails and slugs in a rather curious way. The outer parts of their stems and leaf-stalks contain bundles of excessively sharp crystals (*raphides*), composed of oxalate of lime [146-7]. These pierce the soft mouths of snails and slugs like so many needles, conveying a lesson which is usually taken to heart.

Readers who have followed this Course will realise the importance of the fertilising dust known as pollen. As it is very liable to be spoilt by moisture, a number of devices have come into existence by which this is prevented.

Flowers that Bend to Shield their Pollen. Bell-shaped or cup-shaped flowers hanging upon curved stalks protect their pollen very effectually, as may be seen in Canterbury bell (*Campanula*), heath (*Erica*), snowdrop (*Galanthus*) [135], and lily of the valley (*Convallaria*). There are also many flowers which bend over in rainy weather so as to shield the pollen, among which are herb Robert (*Geranium Robertianum*), daisy (*Bellis perennis*) [137], willow herbs (*Epilobium*), and wood anemone (*Anemone nemorosa*). In other cases, such as those of the lime (*Tilia*) and balsam (*Impatiens noli-me-tangere*), the foliage-leaves serve as an umbrella.

In many members of the dead-nettle and foxglove orders (*Labiatæ* and *Scrophularineæ*) the opening of the corolla is at the side; or in some of the latter, such as toadflax (*Linaria*) and snapdragon (*Antirrhinum*) [134], it is completely closed except during insect visits.

The closing of many flowers on the approach of rain is a common device by which pollen is protected, and is exemplified by roses, gentians, and crocuses [136].

Protection against Unbidden Guests. While flowers lay themselves out, so to speak, to attract insects of a certain kind which are able to transfer pollen, the flowers themselves, or the pollen and nectar they provide as rewards for their industrious servants, prove tempting to other insects, and sometimes to snails and slugs, which are unable to perform the work required of them. Such "unbidden guests" are debarred from access to the flowers by a great variety of ingenious devices.

The flower must also be protected against unbidden guests which approach from the ground. These are mostly creeping insects, which find their upward progress barred by water barriers, slippery or sticky surfaces, or obstructions of bristles or sharp hairs. In certain teasles (*Dipsacus*), for instance, the foliage-leaves are in opposite pairs, and their bases unite together to form a cup in which water accumulates.

Sticky Stems. Some of the catch-flies (*Silene*) and campions (*Lychnis*) have sticky stems, which not only prevent the visits of undesirable forms, but entangle and hold them so firmly that they perish miserably [138]; and in gooseberry (*Ribes grossularia*) there are viscid hairs on the calyx which answer the same purpose. In certain willows (*Salix*) approach to the flowers is prevented by wax-covered slopes as slippery as glass, which give no foothold, while a curved flower-stalk, such as that of snowdrop (*Galanthus nivalis*) [135], may debar entry. Obstructions are well seen in the prickly bracts which closely invest the flower-heads of thistles.

There are some plants, such as certain balsams (*Impatiens*), that secrete nectar at the bases of their foliage-leaves to attract unbidden guests which are climbing up to the flowers. Ants, in particular, are very fond of sweet substances, and commonly content themselves with this lure, which saves them the trouble of going farther [139]. Snails and slugs are effectually kept away by spines, thorns, and prickles, as in gorse (*Ulex Europæus*), sea-holly (*Eryngium maritimum*) [141], and many others. These unbidden guests do not seek pollen or nectar, but devour the flowers bodily.

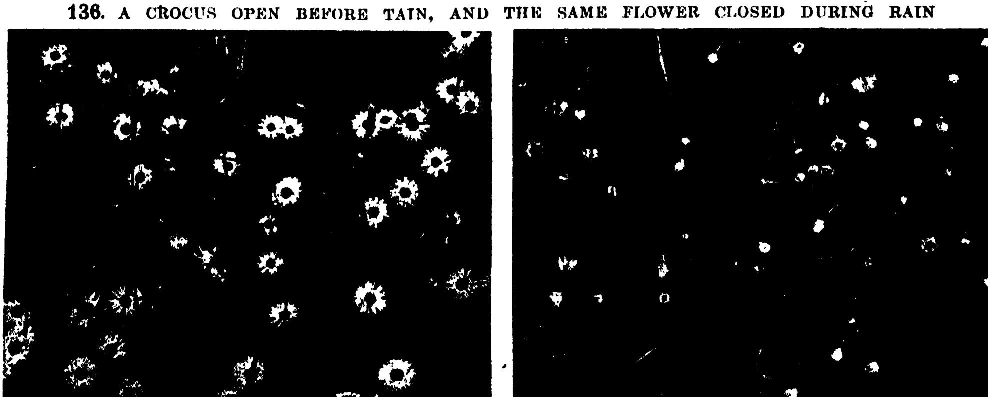
Many of the more specialised flowers can only be usefully served by a limited circle of visitors,

PLANT PROTECTION AGAINST THE WEATHER

134. SNAPDRAGON

135. SNOWDROP

136. A CROCUS OPEN BEFORE TAIN, AND THE SAME FLOWER CLOSED DURING RAIN



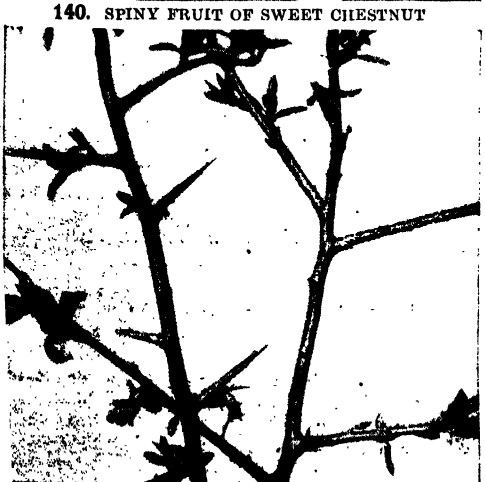
137. A GROUP OF DAISIES, OPEN BY DAY AND CLOSED AT NIGHTFALL
Some of the photographs on these pages are by Mr. J. J. Ward

138. FLIES ADHERING TO THE STICKY AREAS ON THE STEM OF LYCHNIS VISCARIA

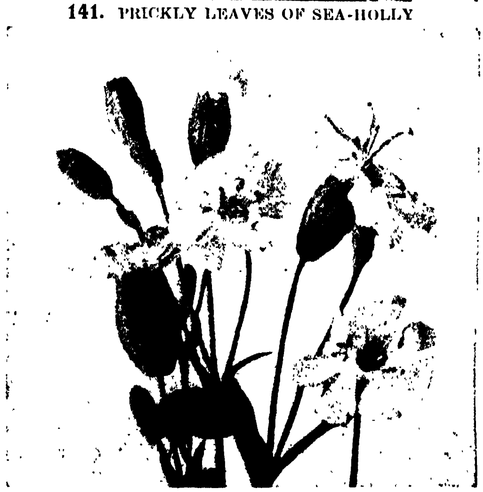
139. ANT SIPPING NECTAR FROM THE STIPULES AT THE BASE OF A VETCH LEAF

140. SPINY FRUIT OF SWEET CHESTNUT

141. PRICKLY LEAVES OF SEA-HOLLY



142. SPINY BRANCHES OF THE SLOE



143. BLADDER CAMPION SHOWING INFLATED CALYX

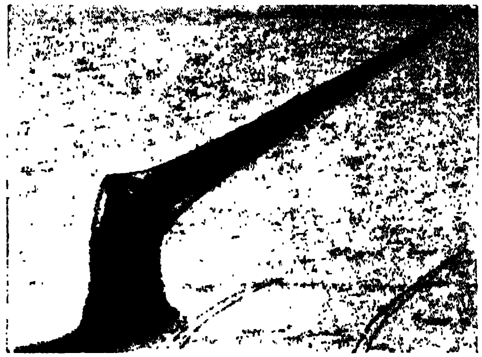
and others have to be excluded. Tangles of hairs or gratings of bristles are often found within the flower itself [144], and effectually protect the nectar against smaller and weaker insects. Such may be found in the buckbean (*Menyanthes*), some honeysuckles (*Lonicera*), and some speedwells (*Veronica*), while in many instances the mechanism of the flower may be compared to a lock of which only the legitimate visitors possess the key. This is well exemplified by most members of the pea and dead-nettle orders (*Leguminosæ* and *Labiatæ*).

There are several thieving bees with tongues too short to reach the nectar-stores of certain flowers, and these intelligent creatures have found it possible to bite through the outer investments and steal the desired treasure without earning it. One device for preventing this is found in the bladder campion (*Silene inflata*), where the large, inflated calyx stands at some distance from the treasure-house [143]. Should a nectar-thief gnaw a hole through this it is no better off than before, for its tongue is too short to stretch through to the nectar.

Many flowers of pale hue which court the attentions of moths only exhale a fragrant odour in the evening, when their guests are on the wing, and may even remain closed during the day. In this way they to some extent escape the notice of undesirables. Honeysuckle (*Lonicera*) may serve as an example.

There are also some plants which maintain a body-guard of ants to repel the attacks of voracious beetles, but do no harm to the flowers. These plants belong to the dandelion order (*Compositæ*), and they reward the services of their retainers by nectar, which is secreted by the scales surrounding the heads of flowers.

144. THE HAIRS IN THE FLOWER OF A PANSY
These protective hairs are shown highly magnified. The round object is a pollen grain.



145. THE STINGING HAIR OF A NETTLE
This hair, shown highly magnified, contains acid sap which flows out of the tip when broken.

We have seen that many fruits are destined to be eaten by birds or other animals, the strongly coated seeds escaping digestion. But it is necessary that such fruits should be protected while they are ripening. For this purpose many of them are enclosed in prickly husks, as sweet chestnut (*Castanea*) [140] and beech (*Fagus*). Still more commonly the unripe fruit is acid, bitter, or even poisonous, and is thus effectually shielded from most attacks. Seeds, when mature, are frequently so flavoured that they do not commend themselves as an article of diet.

146. BUNDLES OF OXALATE OF LIME IN THE LEAF-TISSUE OF ENCHANTER'S NIGHTSHADE

147. PROTECTIVE SILICEOUS HAIRS ON THE LEAVES OF ONOSMA TAURICUM

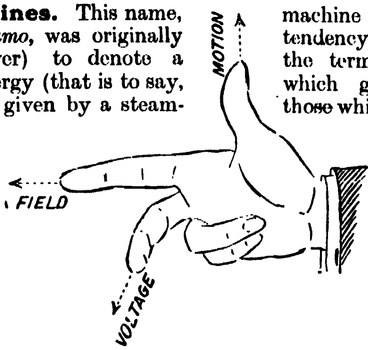
Certain other methods by which fruits and seeds are protected have been already spoken of in the section on "Dispersal" (page 883).

J. R. AINSWORTH-DAVIS

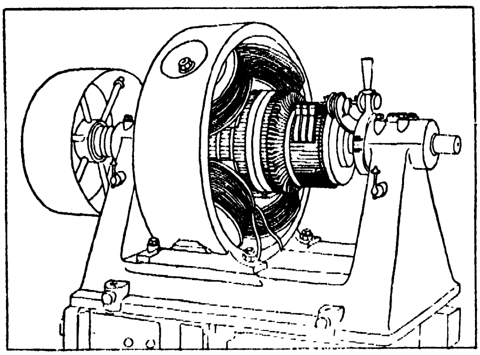
Mechanical Generation of Currents. Field Magnets and Armatures. Commutator and Brushes. Armature Windings.

THE DYNAMO

Dynamo-electric Machines. This name, familiarly shortened into *Dynamo*, was originally coined (Greek *dynamis*, power) to denote a machine in which dynamic energy (that is to say, mechanical energy such as that given by a steam-engine or a turbine) is employed to produce an electric current. In recent years the term has been used, in its general sense, to include all machines the action of which is dependent on the principle discovered by Faraday in 1831, as explained in the preceding article, page 888. That principle was the induction of electric currents by the movement of copper conductors near the poles of magnets in such a way that the conductors cut through the invisible magnetic lines proceeding from the magnet poles. Faraday himself called such machines *magneto-electric*, and this adjective is still retained to denote those machines having a permanent magnet of steel, though Faraday did not so restrict its meaning, but applied it to cases in which steel bars, lodestones, electromagnets, and even the earth itself, were used as magnets. In Germany it has been the fashion to narrow its use to the particular class of machines in which the magnetism is excited by the current generated in the machine itself. On the other hand, the tendency in England now is to confine the term *dynamo* solely to machines which generate continuous currents, those which generate alternating currents being described as *alternators*, but to include those continuous current generators of which the magnetism is independently excited as well as those in which it is self-excited.



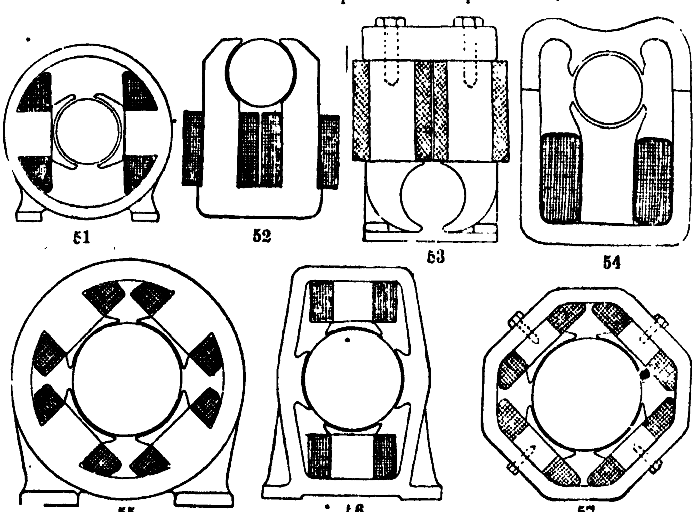
49. RULE OF THE RIGHT HAND



50. A MODERN DYNAMO

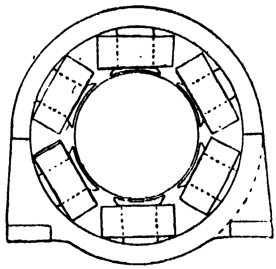
In most dynamos the copper conductors move, while the magnets are stationary; in some the magnets revolve while the copper conductors are stationary, but in the case of continuous current generators this is rare. It is even possible to design dynamos in which both parts revolve, but in opposite directions.

Principle of Reversibility. One most important fact about the dynamo—and it is true of all its many forms—is its reversibility of function. When driven by mechanical power it generates electric currents, but when supplied with electric currents it generates mechanical power. The very same machine that will serve to convert mechanical energy into electrical energy, as a *generator*, will also serve to convert electrical energy into mechanical energy as a *motor*. In fact, it possesses reversibility of function. This is indeed a most precious property, and is made use of in the electrical transmission of power from place to place.



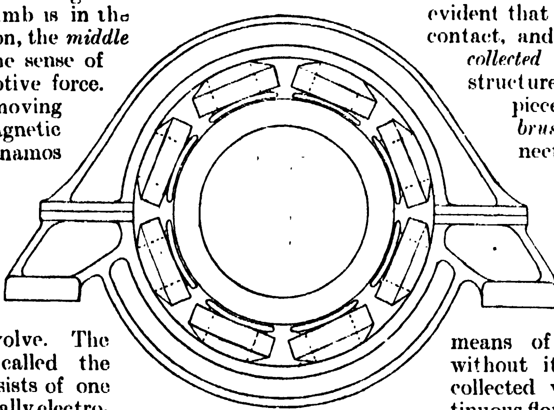
51–57. FORMS OF FIELD-MAGNETS

Right-hand Rule for Induction. The induction of an electromotive force in a moving wire, or conductor, tends to send a current along that wire in one direction or the other, and this direction can always be ascertained. In the movement of the conductor laterally across the magnetic lines, we have three things mutually at right-angles to one another—the magnetic lines, the direction of the movement, and the direction of the electromotive force. Now imagine the forefinger, the middle finger, and the thumb of the *right hand* to be set to point in three directions mutually at right angles to one another, as in 49. Then, if the forefinger is set to point along the direction of the magnetic field, and if the thumb is in the direction of the motion, the *middle finger* will indicate the sense of the induced electromotive force. This is true for all moving conductors in magnetic fields, whether in dynamos or motors.



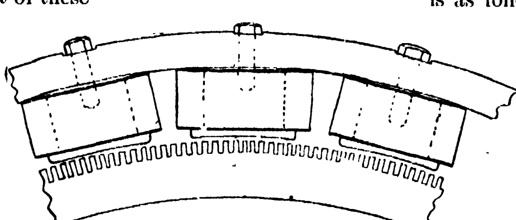
58. SIX-POLE FIELD-MAGNET

Field-magnets and Armatures. Every dynamo consists of two principal parts, one of which stands still, while the other is made to revolve. The stationary part is called the *field-magnet*. It consists of one or more magnets, usually electro-magnets (page 495) firmly fixed in an iron frame the object of these magnets being to create a magnetic flux, or, in other words, to create a large number of magnetic lines which proceed from its poles. The revolving part is called the *armature*, and it consists essentially of a number of copper wires, or copper conductors, joined up together and grouped in a particular way for the circulation of the currents; these wires, or conductors being wound upon a core built up of laminated iron. In modern machines the cores are made with projecting teeth, and the copper conductors are sunk in slots between the teeth, and held in tightly by binding-wires or by wedges. The core is keyed firmly upon the revolving shaft, So, when the armature is set revolving, the copper conductors are whirled round at a high speed. The revolving armature occupies a central position, and is surrounded by the poles of the field-magnet, which send their magnetic lines into the iron core across the intervening gap or clearance. The revolving copper conductors as they fly round cut these invisible magnetic lines, and so, according to Faraday's principle, create or induce electromotive forces. These electromotive forces tend to drive currents along the copper conductors, and so, if the revolving conductors are connected to a circuit, currents will be generated.

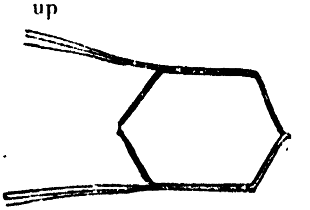


59. EIGHT-POLE FIELD-MAGNET

Commutator and Brushes. There arises, then, the problem how to connect the conductors of the revolving armature to the wires, or mains, of a circuit. It is evident that this entails a sliding contact, and the current must be *collected* from the revolving structure by means of contact-pieces, technically called *the brushes*, which are connected to the mains, and which press against the revolving structure.



60. PORTION OF A 24-POLE FIELD-MAGNET



61. AN ARMATURE COIL

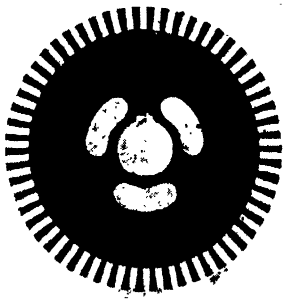
The commutator, however, performs a function much more important than acting merely as a means of gliding contact, for, without its aid, the current collected would not be a continuous flow like the current from a battery. The reason for this is as follows. The poles of the field-magnet are of two sorts, north poles and south poles, arranged alternately. Since the revolving conductors on the armature are moved first past a north pole, then past a south pole, then past another north pole, and so on in continual succession, it follows that the induction of voltage in the conductors will continually reverse, and reverse back. For we may regard each north pole as sending out a flux of magnetic lines across the air gap into the body of the armature, from which these lines emerge to return into the south poles. Hence, if we apply the right-hand rule to the various cases, we shall see that the induction taking place in the conductors will alternate in its direction along the wire. This process, therefore, sets up alternating currents in the armature wires; and, unless these currents were commuted, they would be in a perpetual alternation in the mains of the circuit.

62. A COMMUTATOR SEGMENT

It is the function of the commutator to commute, or change, these alternating currents that exist in the armature, and deliver them to the external circuit as a "continuous" current. By *continuous* is meant *flowing steadily in one direction,* like the current from a battery. Some engineers call such a current a *direct* current, though its process of generation is thus indirect. The term "continuous" is more correct. How the commutator performs its work we shall see presently.

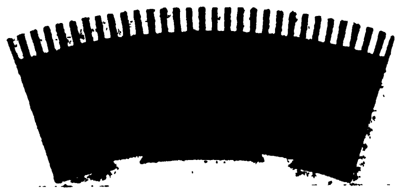
A Modern Dynamo. All essential features of a modern dynamo can be observed in the machine depicted in **50**. On the left is a pulley by which it can be driven by a belt from a steam-engine. The shaft is supported by bearings standing upon pedestals which rise from a strong cast-iron bed-plate. Between the pedestals stands bolted to the bed-plate the *field-magnet* system, consisting of a circular frame, or yoke, of cast steel, from which there project inwardly four massive magnet-poles, each surrounded by its magnetising coil. Between these four poles the *armature* revolves—a substantial barrel-like, or cylindrical, structure. At the right-hand end of the armature is the *commutator*—easily identified by noticing that it is a smaller cylinder built up of a number of parallel bars, or segments, of copper. Upon the commutator press the *brushes.* Of these there are two sets, of three brushes per set. The set of three in front can be seen clamped upon a short, horizontal rod, which projects to the left from the curved arm of the *rocker,* or frame, which carries the brush sets. The other brush set is behind the upper part of the commutator.

This particular machine is designed to run at 640 revolutions per minute, and to give out a current of 80 amperes at 250 volts. It will, therefore, at full load give an output of 250×80 watts—that is, 20,000 watts, or 20 kilowatts. And that it may do this one must put into it mechanically at least 20 kilowatts of mechanical power. Now (p. 232), 1 kilowatt = 1·34-horse power; therefore this machine will require $20 \times 1{\cdot}34 = 26{\cdot}8$ horse power at least. But in all machines there are certain losses due to friction, resistance, etc. If this machine has an efficiency of 94 per cent., then to get the 20 kilowatts (which are the equivalent of 26·8 horse power) out of it, we must put into it $26{\cdot}80 \times 100 \div 94 = 28{\cdot}5$-horse power.

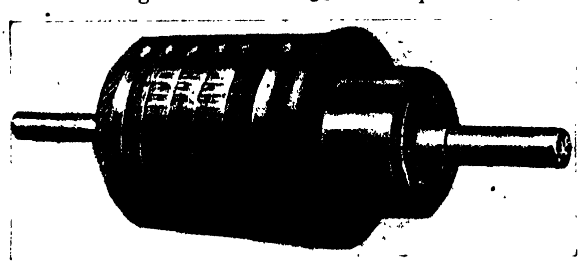


63. ARMATURE CORE-DISC (Sankey and Sons)

Forms of Field-Magnets. Almost all modern dynamos have four or more poles, but many old generators and many small motors of recent date have but two poles. Fig. **51** illustrates a *bipolar* form, suitable for small, enclosed motors, having the pole-cores projecting inwardly from the surrounding yoke. Figs. **52** and **53** illustrate other bipolar forms, the field-magnet being here a species of horseshoe, with its poles upward or downward. This form is still met with in open motors. Fig. **54** is a further development, in which the whole of the exciting coil is wound upon a single core. *Multipolar* forms are preferred for all large machines, and are illustrated in **55** to **60**. Fig. **55** is a four-pole form, practically identical with the magnets of **50**. Fig. **56** is a more special form, in which two of the poles only are wound with exciting coils, the other two being left unwound. Fig. **58** is a six-pole form, often used for machines of 100 to 300 kilowatts. Fig. **59** is an eight-pole tramway generator; it shows how the casting is divided into an upper and a lower half, and how the whole frame is supported. Fig. **60** gives a view of three poles of a large 24-pole generator of 2,000 kilowatts (2,680-horse power). In these large sizes the frame is stiffened by two projecting ribs that run round it. In many cases the ends of the poles next the armature are enlarged by the addition of *pole-shoes.* Fig. **57** is a four-pole form, made very compact, of the pattern much used for tramway motors.

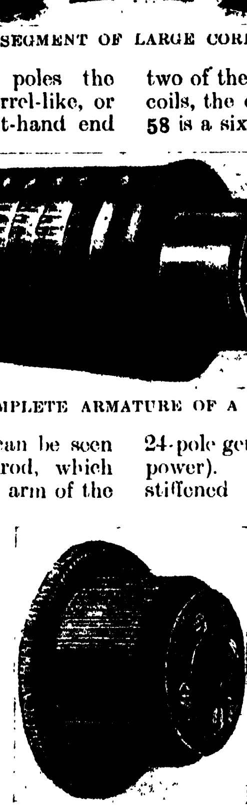


64. SEGMENT OF LARGE CORE-DISC



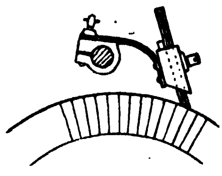
65. COMPLETE ARMATURE OF A DYNAMO

Armature Cores. The core-body which receives the copper winding is nowadays always built up of thin *core-discs,* or stampings of very soft sheet steel, about $\frac{1}{50}$ in. thick. In small machines these core-discs are stamped out in one piece, like **63**, which has a central hole to admit the shaft, and ventilation holes. It is toothed at the periphery in order that when these discs, to the number of



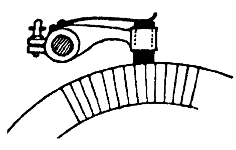
66. COMMUTATOR

some hundreds, have been assembled on the shaft, the core body shall be furnished at its outer part with a series of longitudinal grooves, or *slots*, in which the copper windings can be placed. For armatures that are over 3 ft. in diameter the cores are built up of segments of thin steel, like **64**, attached by bolts or dovetail clampings to a central hub. The object of thus building the core bodies of assembled laminations is to prevent the waste of energy and consequent heating, which would occur by reason of parasitic currents induced in the mass if it were of solid iron. The thin sheets must be lightly insulated from one another by paper or lacquer.



67. A COPPER BRUSH

Armature Windings. The conductors that are to be coiled on the core consist, in small dynamos, of copper wire, cotton-covered, and well lacquered. In very large machines they consist of drawn copper strip insulated by a covering of tape and lacquer. The proper number and arrangement of these conductors will presently be considered. In modern standard machines the coils of the armature are shaped upon wooden moulds, or *formers*, prior to being put into their places in the slots. Fig. **61** shows such a coil, consisting, in fact, of three separate coils taped up together for convenience in handling. They are curiously kinked, or twisted at the end-bends to permit of their being assembled in the slots, overlapping one another, each slot receiving two "sides" of coils, lying one above the other in the slot.



68. A CARBON BRUSH

Re-entrant Windings. The coils, after being put in place, are joined up together in a particular order, the end of one being joined to the beginning of the next, so that they form a continuous series, the end of the last one being finally united to the beginning of the first, and the whole series becoming, therefore, one re-entrant circuit. If a current be brought to any point of a re-entrant circuit, and leave that circuit at any other point, it will obviously have two possible paths of flow from the one point to the other. In every armature there are, therefore, at least *two paths* through the windings; and, as we shall see, there are often *more than two paths.*

69. BRUSH GEAR AND ROCKER

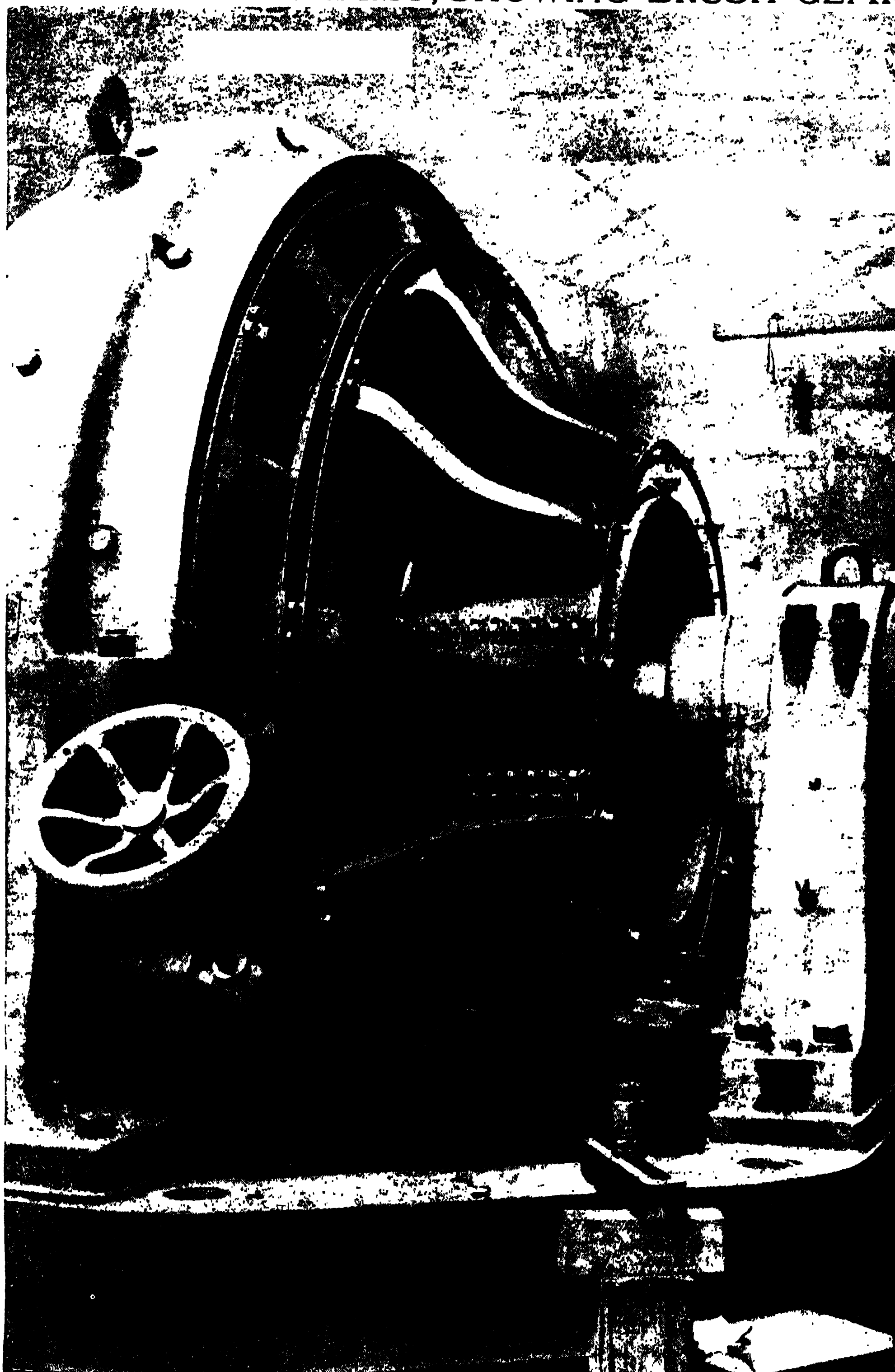
Winding Pitch. Consider any loop of the winding, such as the loop shown in **61**. If a current is flowing around such a loop, it obviously will flow up one side and down the other. To drive the current around the loop by its own inductive action, as it whirls past the poles, it ought clearly to be of such a breadth from side to side that, while one side is passing under a north pole, the other side ought to be passing under a south pole, and then the two electromotive forces induced will help one another to drive the current around that loop.

Commutator Construction. The commutator consists of a number of bars, or strips, of copper, of a slightly tapering section assembled together to form a cylindrical structure, as depicted in **66**. The separate bars are insulated from one another with strips of mica, about 0·030 in. thick, interposed between them. The bars are shaped like **62**, with dovetail corners on their under side, so that they can be securely clamped between end-cheeks, and mounted on a shell, or hub, that is secured on the armature shaft. Insulating collars of built-up mica are interposed between the bars and the clamping cheeks of the shell, so that each individual bar is electrically isolated from contact with the neighbouring metallic parts. At the end of each bar of the commutator is attached a metallic strip, called a *riser*, by means of which the bar is connected to the armature windings. Thus, if the commutator has, say, 111 bars, there will be 111 risers connected to the winding, at 111 equidistant points.

Fig. **65** shows an armature complete, with the commutator. The dark markings show ventilating ducts between the windings. The end-bends, as well as the wires in the slots, are held down firmly by numerous bands of steel *binding wires.*

Brushes and Brush Gear. The name *brushes* was given to the stationary contact-pieces which collect the current from the commutator, because in the early machines they were literally made of bundles of springy brass wire. Nowadays, they are either made of bundles of *copper gauze* or copper strips, clamped in suitable *brush-holders* [**67**], or more often of blocks of fine *carbon* [**68**], held in holders, which press with a springy pressure upon the surface of the revolving commutator. In order to adjust the brushes to the proper position to collect the current without sparking, they are fixed to an adjustable frame called the *rocker*, which is itself borne upon the bearing, or else bracketed out from the magnet frame. Fig. **69** depicts a *brush rocker*, showing four sets of carbon brushes together with the pieces of flexible cable to connect them together, two and two, and to carry off the current to the circuit. There are two carbon brushes in each set. Fig. **70** depicts the *brush gear* of a much larger machine, having no fewer than 120 carbon brushes, arranged in 12 "sets" of 10 brushes

A MONSTER DYNAMO, SHOWING BRUSH GEAR



70. A 2000-KILOWATT AND 500-VOLT GENERATOR OF THE COMPENSATED TYPE
From a photograph by courtesy of the British Westinghouse Electric and Manufacturing Company

per set. Carbon brushes will collect from 30 to 40 amperes for each square inch of contact surface. Copper brushes need only about one-third as much contact surface as carbon brushes.

Calculation of Magnet Windings. To excite the magnetism in the dynamo, coils must be wound upon the pole-cores of the field-magnet; or, rather, coils must be prepared with the proper number of windings of wire of the right thickness and with the right number of turns, being wound up on a lathe, and afterwards slipped into their places on the pole-cores. It is evident, therefore, that some previous calculation is necessary to enable the engineer to ascertain what windings will be right for any particular machine. Such calculations are made in two stages: first, to find the total amount of excitation, in *ampere-turns* [see page 496], that will be needed; after that, to ascertain the particular size of wire and number of coils that will answer this need.

Conception of Magnet Circuit. It was pointed out on page **497** that if in any magnetic circuit there are gaps—that is, if the magnetic lines have to emerge from the iron core into the air to cross the air-gap and then re-enter the iron—it will be necessary to provide a much greater circulation of current than would suffice to magnetise to the same degree if there were no gaps. The reason of this is that iron is much more permeable to magnetism than air is. Now, whenever the question arises how many *ampere-turns* of excitation are necessary, one must examine two preliminary conditions—namely, what is the nature of the magnetic circuit, and how great a flux is to be produced therein. In a simple horseshoe electromagnet, such as **26** [page 495], the magnetic circuit, or path, consists partly of iron, partly of air. The magnetic flux which emerges from the north-pole surface crosses a gap into the iron keeper, traverses the keeper, emerges again into the air opposite the south pole, crosses the gap again, and re-enters the iron core at the south pole, and follows the iron arch round to the north pole again. In a bipolar dynamo, such as **52** or **53**, the magnetic circuit is much like that of the horseshoe electromagnet, except that the gaps are very narrow. In a multipolar dynamo, such as **50**, **59**, or **60**, there are a number of independent magnetic circuits. For instance, in **60**, if the middle pole is the north pole, the magnetic flux that comes down the middle pole-core and crosses the gap into the armature core will divide, half the lines going to the right and recrossing the gap to go up the right-hand south-pole core, the other half going to the left to recross the gap under the left-hand south-pole core. In all such cases we have to calculate separately the excitation needed to send the flux through the different parts, and we must then total up the result for a whole magetic circuit.

The calculation is complicated by the circumstance that there is always a little magnetic *dispersion*—that is, some of the flux which emerges from the pole does not cross the gap and enter the armature, but leaks by some lateral path to the neighbouring south poles. By experience we can ascertain how much to allow as a *leakage coefficient*. In ordinary multipolar dynamos 20 per cent. is an ample allowance.

Rules to Calculate the Excitation. For air-gaps, the rule is that the necessary ampere-turns, per inch, are equal to the flux-density in the gap multiplied by the *gap coefficient* 0·3133. In any iron part we have to calculate by reference to curves of statistics of the magnetism of iron of similar quality, and find from such curves how many ampere-turns per inch length of path are needed to produce in that kind of iron the required flux-density, and then multiply up the figure so found by the number of inches' length of that part.

For example, if we had the four-pole dynamo [**50**] ready built, but still requiring its winding, we should know that the flux from the pole was to be 2,700,000 lines net, or (allowing 20 per cent. for dispersion) 3,240,000 lines in the poles core. Further, if the area of pole surface is 56 sq. in., the flux-density in the air-gap will be 48,000 lines per square inch. Also, if the pole-core section is 50 sq. in., the density in the iron will be 65,000 lines per square in. Moreover, if the teeth are so narrow that the effective section of those under one pole is only 20 sq. in., the density in them will be 135,000. Now, suppose the air-gap to be half an inch wide, the teeth one inch long, the pole-core eight inches long. Also suppose the curves of statistics to show that to produce a flux-density of 65,000 in the mild steel of the pole-cores required 14 ampere-turns per inch, and to produce a density of 135,000 in the armature stampings required 1200 ampere-turns per inch, we then have the following calculation for a magnetic circuit:

A.-T needed for	2 air-gaps	= 2 × 48,000 × 0·3133 × 0·5	= 15,038
A.-T ,,	2 teeth	= 2 × 1,200 × 1	= 2,400
A.-T ,,	2 pole-cores	= 2 × 14 × 8	= 224
A.-T needed for one piece of core-body and one piece of yoke, say,			= 800
Total ampere-turns needed per pair of poles			18 462

Hence, each pole must carry wire enough to provide 9231 ampere-turns.

To find the right size of wire we have the rule that it must be such that its resistance per inch length will be equal to the voltage divided by the required number of ampere-turns and by the mean length per turn of the coil. Now, this dynamo is for 250 volts, so that there will be available (allowing 30 volts for regulating rheostat) 220 volts—that is, 55 volts for each of the four coils. The mean length of one turn will be about 35 in. Hence the wire must have a resistance of $55 \div (9231 \times 35) = 0{\cdot}00017$ ohms per inch length. This will be a No. 15 S.W.G. wire, the diameter of which is 0·072 in.

In case any such calculation results in requiring a wire that does not exactly correspond to any particular size of standard gauge, the standard wire of the next larger size should be taken.

SILVANUS P. THOMPSON

Transposing at Sight and on Paper. Changing Accidentals. Reading by Intervals. Score Reading. Transposing Instruments.

TRANSPOSITION

THE art of transposition is not modern. In the days of Greece Claudius Ptolemy transposed the "Hymn of Memesis" from the old high pitch of the scale of Alypius a fourth lower. But the Greek system of musical notation was different from ours, though in certain respects analogous, because the modern tone-system has been partly evolved through the old ecclesiastical modes.

Ancient Methods of Transposition. In old missals dated A.D. 1300–1400, transposition from one mode to another was regulated by the distinctive colouring of certain of the notes. Coming to later times, Loulié, a French musician, wrote an ingenious book in 1698 published by Estienne Roger, of Amsterdam. In this the author explains the nature of transposition, and sets forth a method of reducing music into any of the keys denoted, either by the acute or grave signatures, and translating them back again into the original, or radical, keys.

Definition. In music, the word transposition has several meanings, but its usual signification is the rendering of a composition in another key than that in which it is written. This is done either by copying out, singing, or playing a piece by altering the pitch equally from start to finish—whether a semitone, tone, major or minor third, higher or lower, as may be desired. [See THEORY OF MUSIC.]

Transposing on Paper. To alter the key in which a piece is composed by translating it into a different scale is easy enough on paper. Such pen-and-ink exercises should always supplement a student's practical studies. In order to master his instrument, he should practise each study in as many different keys as possible. The most economical way of getting the notation for this is to transpose the exercise on paper.

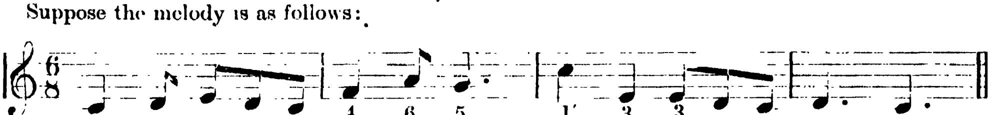
The first point is to find the new tonic, or keynote. After this has been done, alter the key signature accordingly. The rest in a straightforward diatonic composition is a matter of carefully copying out each note at an equal distance above or below the original.

Transposing Melodies. Taking the notes of the three centre octaves of a piano—of which the C just over the lock gives the middle, or first ledger line C beneath the G clef—substitute the numbers 1 to 7 for the letters C to B inclusive. Employ ordinary numerals for the centre, or 2 ft., octave. Add an acute accent to each figure upwards in the next, or 1 ft., octave, two accents for the 6 in. treble octave, and three accents for the 3 in. high treble octave. To discriminate the lower notes, attach a single comma below each number in the 4 ft. octave, two commas to each in the 8 ft. bass octave, and three in the 16 ft. low bass octave.

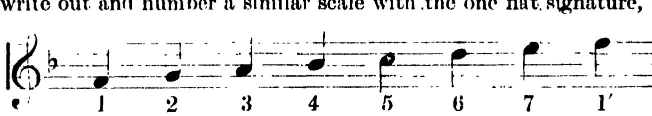
Intervals. Such numbers represent intervals which are alike in all keys although the names, or letters, of the notes alter. Number the scale of C major thus:

8 ft. octave. 4 ft. octave. 2 ft. octave. 1 ft. octave.

Suppose the melody is as follows:



It is required to be transposed, say, a fourth. A fourth above C is F. F major has one flat—B. Beginning at F, write out and number a similar scale with the one flat signature, thus:



The student, who may know nothing of music, by taking these numbers and writing the notes in their new places, will be able to transpose the melody correctly from C to F, thus:

The first essential, therefore, is to recognise quickly the distance of each note from the first, or tonic, of the scale. By inscribing simple exercises of one octave, and transposing the notes systematically into all the keys, the beginner will soon become accustomed to reckon with the eye the proper position for each note, and will then be able to dispense with the figures.

Obviously, the transposition on paper of any diatonic melody presents no difficulty to the scribe, since all that has to be done is to calculate the higher or lower position needed for each note.

Transposing at Sight. It is, however, not infrequently the case that a pianist or organist is required to transpose a piece of music at sight to suit a singer. The task is then more arduous. But it has to be done. For that reason, candidates for examination for the Incorporated Society of Musicians, the Associated Board, the Royal College of Organists, and other institutions, are required to show reasonable ability in this respect.

Concert Pitch. When, in 1896, the London Philharmonic Society discarded the high military pitch, and came into tune with the music of the Continent by lowering the British standard to the note represented by A, giving 439 entire vibrations per second when tested at a concert-room temperature of 68 degrees Fahrenheit, the change was widely welcomed by singers, whose voices were unnecessarily strained by the military band pitch. But, owing to the great expense of re-tuning and re-voicing large organs, it happens to-day that when musicians reinforce a church choir with wind instruments at the new pitch, or if the organ has been altered and bandsmen bring in instruments at the old pitch, the organist is forced to transpose at sight a semitone lower or higher, as the case may be.

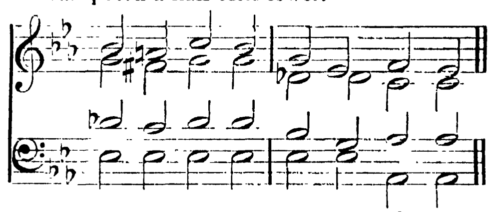
He cannot, like the guitarist, alter the pitch of his instrument by putting on a capotasto, neither can he adopt the device of the violinist called the scordatura, and thereby deviate from the ordinary tuning as required.

Extreme Keys. Usually, all that is wanted is to transpose a semitone up or down. In this case the task is comparatively easy. Taking C major and A minor as the normal scales of our musical system, all the pianist or organist has to do when required to raise the pitch half a tone is to change mentally the signature to C sharp major or A sharp minor. Should the sounds have to be lowered, the transposer imagines that the signature is C flat major or A flat minor. It may be argued that extreme keys, bristling with sharps or flats, are very difficult. That depends on whether the student has, or has not, taken the trouble to accustom himself to them. He will now perceive, in a way which may not have been before apparent, why it is advantageous to practise as often as possible scales which have many accidentals.

Changing Accidentals. To understand this method of transposition, it is better not to begin with C or A. Take a hymn in the key, say, of E major, like Barnby's "St. Hilda." To transpose it down to E flat major, obliterate from the mind the printed signature of four sharps. In their place think of the three flats B, E, and A. Then play the music as written, except when an accidental occurs. As the key is lowered half a tone, whenever a natural arrives in the music the mind must transform that natural into a flat. When a sharp comes along, imagine that it is a natural. In the same way, a double sharp must convert itself into a single sharp, and a single flat into a double flat. We have only space here to quote the 5th line:

"St. Hilda." BARNBY.

Transposed a half-tone lower.

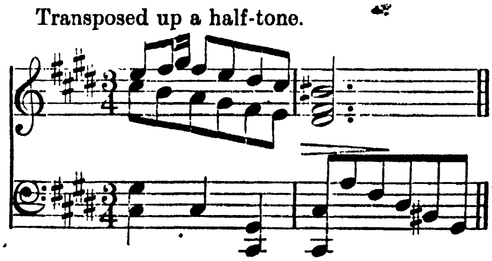


On the other hand, if the hymn chosen is in E flat major, and has to be transposed a semitone upwards, the mental process is reversed.

Obliterate from the mind the signature of the three flats. In their places substitute the four sharps F, C, G, and D. Wherever a natural occurs on the printed page, it must become a sharp. A flat changes into a natural, a sharp into a double sharp, and a double flat dissolves into a single flat.

"St. Matthew." BACH.

Transposed up a half-tone.



Reading by Intervals. It is when we come to transposition at intervals of a third,

fourth, fifth, and so on, higher or lower, that the task of the reader increases in difficulty. On such occasions the player must be either well acquainted with the rules of harmony or familiar with the piece before he attempts to transpose. The eye then reads by intervals rather than by actual notes. Infant prodigies at the piano can go to the instrument and play by ear melodies they have heard with appropriate harmonies. Usually they are capable of playing the tune in any key they fancy. This gift comes naturally to them, It is called "playing by ear." The child cannot analyse the way in which the result is obtained. But the moral of this is that the younger the student happens to be, the better is his chance of becoming a skilful transposer if he gives his mind, while it is yet plastic, to this useful branch of musical study.

In transposing to a key more than a semitone higher or lower, the player who has studied harmony does not trust to chance. He takes his cue from the lowest note. From that he builds up the superstructure grammatically. To do this requires, with most players, long and constant practice. A privileged minority seems to develop the knack by instinct. With such players, as in the case of that ideal accompanist Mr. Henry Bird, transposition is always made artistically. The best part of the pianoforte is, or should be, its middle register. To transpose a piece a fifth, sixth, or seventh lower than it is written may entirely alter the character of an accompaniment, and cause it to sound lugubrious in a way never intended.

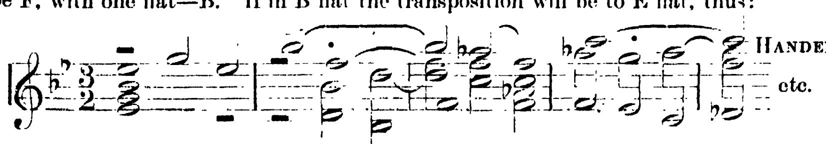
Retaining the Composer's Intention. This is one of the objections musicians have to mechanically transposing keyboards, the main one, of course, being that they cannot take such contrivances about with them like fiddles. By occasionally altering the disposition of the written notes in arpeggios or chords, the accomplished accompanist contrives to enhance the effect of the voice, and communicate the nature of the original composition, thus retaining the intention of the composer. The class of musician most accustomed to transposing at sight is the orchestral player. For him it is less difficult than the pianist. He reads from only one stave, and usually a succession of single notes.

The "C" Clefs. The pianist ordinarily confines his attention to the treble and the bass clefs. But the studious instrumentalist who has made himself conversant with the various C clefs is able to use these when transposing at sight, and thus save himself all trouble of calculating intervals. In the days of Purcell these extra clefs were common in vocal music. With the exception of the tenor clef, they are now seldom used. Instead of C being indicated on the first ledger line below the staff, as it is when our G, or treble, clef is used, the soprano clef places that note on the first line, the mezzo-soprano clef causes it to rest on the second line, the alto on the third line, and the tenor on the fourth line, thus:

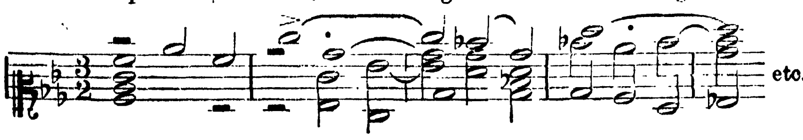
The Soprano Clef. The music transposes itself automatically by substituting the soprano C mentally for the treble G clef, and playing the notes as written, remembering the requisite accidentals for the new signature. Read in this manner, the substituted clef causes the music to sound a third lower or a sixth higher. Thus, if the original is in C major, it is now heard in the key of A major. Therefore, every F, C, and G must become sharp.

The same notes transposed a third lower, or a sixth higher if "8vo" is imagined above them.

The Mezzo-soprano. When the mezzo-soprano C clef mentally supersedes the G treble clef, and the signature of the new key is borne in mind, the player is able to render the printed notes at once a fifth lower or a fourth higher. Consequently, if the original is in C, the key will now be F, with one flat—B. If in B flat the transposition will be to E flat, thus:



The same notes transposed a fifth lower, or fourth higher if an "8vo" is imagined above them.



The Alto. Reading in the alto in place of the G clef, the player transposes a seventh lower or a second higher. A piece written in C major, but taken in the alto clef, will thus sound in D major, with two sharps—F and C.

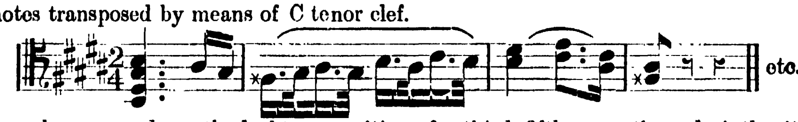
HAYDN.

Same notes transposed a seventh lower, or second higher if an "8vo" is imagined above them.

The Tenor. In the same way, the player can transpose music written in the G clef a ninth lower by reading it in the tenor clef, so that a piece in C major played in the tenor clef (giving 2 ft. C on its fourth line) will sound in the key of B, with five sharps—F, C, G, D, and A; in other words—irrespective of octave pitch—a second lower or a seventh higher:

BEETHOVEN.

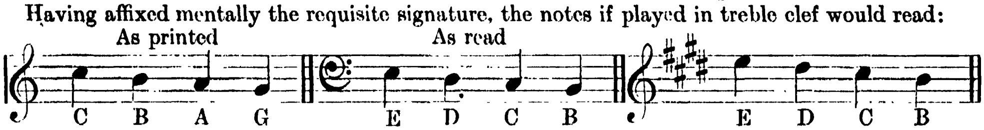
Same notes transposed by means of C tenor clef.



So here we have a ready method of transposition of a third, fifth, seventh, and ninth without the trouble of calculating intervals.

The Bass. But the resources of the instrumentalist are not yet exhausted. If he obliterates the G clef and puts in its place the F, or bass, he lowers the tone a third. But he must then read the sounds a double octave higher than they are written. Supposing the key of the original to be C major, the note sounded will now be in A, with three sharps—F, C, and G.

Having affixed mentally the requisite signature, the notes if played in treble clef would read:



The intelligent student will not lack employment, no matter what instrument he takes up, if he translates systematically the exercises he practises into different keys by means of the various C clefs. When reading the notes with any C clef, the sound can be also transposed, either up or down a semitone, by making mentally a further variation in the signature, in the manner already explained. But this must not be attempted before the student has accustomed himself to reading various exercises in the old vocal clefs and the bass.

Score Reading. The student who neglects to make himself acquainted with transposition will never become proficient in reading an orchestral score. To comprehend an old vocal score where the various C clefs are used, the mental process indicated for translating the sound from the G into the C clefs is, of course, reversed by the beginner, in the same way that an English schoolboy learning French at first slowly translates every French word into its English equivalent before understanding it.

A Full Score. If we take a modern full score, we may find some 30 different parts, ranged one above the other. A non-musician, accustomed to read a single line of letterpress from left to right, regards such notation as hopelessly complicated. Yet it is far superior to his own. It conveys not only the exact rhythm and speed at which every syllable should be read, but also the mental mood in which it must be received.

Moreover, musical notation has the gift of brevity. The longest sentence penned can be portrayed vertically in a single sustained chord. If we examine the opening page of a full score, it will be observed that only certain instruments such as the violin, trombones, the oboe and bassoon in C, the harp and organ, play the notes as written. These instruments are called "non-transposing."

Transposing Instruments. On the other hand, the student will observe that the clarionet in A sounds a minor third lower than the printed notes; that the trumpet in E flat expresses itself a minor third higher, and that the horn in D utters its sound a seventh lower. In military scoring there are many such complications. The modern composer, anxious to startle, is, of course, at liberty to avail himself of any and every tone-colour his fancy dictates.

ALGERNON ROSE

Flax and Hemp Production. Jute Growing. Ramie Fibre. Paper as a Source of Yarn.

THE BAST FIBRES

FLAX and wool are the two traditional raw materials of British textile industry, and, had not flax—or linen—been superseded in many directions by the cheaper fibre cotton, it must have filled a larger place today. The replacement is evident from the common speech, for we still speak of bed-linen, although few sleep between other than cotton sheets. *Linsey-woolsey,* the now obsolescent name for union woollen fabrics, points to the time when linen warps were used instead of cotton ones to make mixed woollen goods. Until about 140 years ago, when machine-spun cotton yarn came upon the market, cottons were only one-half cotton, the warp being always linen. The course of subsequent development has confined flax to special uses for which no other fibre is quite so advantageous; but, next to cotton, flax remains the most considerable of the vegetable fibres.

Cotton and Flax Fibre Compared. We have seen that cotton is a seed hair. Flax, upon the other hand, is a bast fibre occurring between the woody stem and the epidermis of a plant. Both are nearly pure cellulose, but owing to the difference in the manner of growth there are marked variations in the cellular structure and in the characteristics which affect the manufacture. Cotton is a short fibre, and flax, in the condition in which it comes into the market, is a long one, 12 to 36 inches in length, but consisting ultimately of short lengths bound together by *pectose* or wax.

Seen through the microscope the flax fibre is found to be pitted along its sides, and these pits act as does the natural twist in the cotton fibre. They prevent the slipping of one fibre over another and assist the formation of yarn.

The Source of Flax. The source of flax is *Linum usitatissimus,* the plant which grows also the valuable commodity linseed. In some parts of the world the flax plant is cultivated solely for seed. This is the case in hot countries, like India, where the fibres grow coarse under the influence of the sun. In North America linseed is often grown as a first crop upon virgin land; and seed crops are raised on virgin soil, or on land that has long lain fallow, in the black-soil provinces of Russia. Seeding exhausts the soil heavily, and when flax is grown for its fibre the seed is not allowed to mature. It is found in Ireland that any soil good enough for wheat, oats, or barley will serve for flax, but crops can only be taken from the same soil at intervals of seven or preferably twelve years apart. In Belgium, where the plant is highly cultivated and from whence the best flax comes, a deep but not too heavy soil is considered best. In dry, chalky soil the stalks grow short; and in heavy clay, although the straw grows long, the fibre is not fine. In Russia, which is the principal producing country and is accountable for about a quarter of a million tons a year, the culture of flax jointly for seed and fibre is found more profitable than that of any ordinary cereal. Flax does not need cutting in harvesting, and it can be grown on any irregular ground on which the surface soil is good.

Flax-growing. The plant is an annual with a slender stem and lance-shaped leaves, and it bears flowers which are normally sky-blue but sometimes white. The flowers are followed by five-lobed globular capsules the size of peas, within which is found the seed. The plants grow two or three feet high, and, in order to restrain their tendency to branch out, it is usual to sow them closely together, so that the branches are confined to the tops of the stalks.

About four months after sowing the yellowing of the straw and the drooping of the lower leaves show that the time is ripe for pulling the plants, and the harvesting begins. Field methods vary in detail in different places, but in all the roots are pulled out of the ground. A sheaf or *beet* is made by tying together a bundle of stems of similar length, the soil is knocked away from the root, and the sheaves are left to dry. After a little while the seed capsules may be torn away or *rippled* off by pulling the head of the sheaf through the spikes of a heavy upright comb, and the grain may be liberated from the chaff by thrashing with a heavy tool. Often the seed is neglected, because when flax is grown for fibre the grain is immature at harvest time. Before proceeding to extract the fibre it is best to stack the stems for one year.

The fibre does not come away willingly, and means have to be taken to detach it from the wood and the bark. A process of fermentation, known as *retting,* is used.

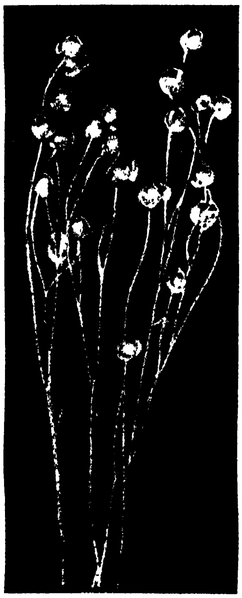
Recovering the Fibre. There are three main methods of retting. The simplest and least advantageous method is dew-retting, as practised in Russia, the United States, and in parts of some other countries. The stems are exposed to the action of dew until the straw is sufficiently decomposed to yield up its fibre freely. Dew-retting gives soft fibre, but as the action is irregular and fermentation proceeds faster in some parts of the stem than in others, the colour, strength, and length are uncertain. The Russian *Slanetz* flaxes are dew-retted, and fetch much less than the pool-retted or *Motchinetz* fibre. Water-retting is best done in rain water, or, at least, in very soft water, free from iron, lime, or salt, as these impurities affect the colour of the fibre and interfere with the result. Pits in

which vegetable matter grows and which have been exposed to the sun for some weeks are suitable for retting; in Ireland farmers sometimes make use of natural bogholes. The better way is to use artificial pits dug with sloping sides. The sides should be straw covered to protect the flax from contamination with dirt, and the sheaves themselves piled upright and root downward until the tank is full. Straw and weights are placed on the top to hold the whole under water, and water is poured in.

The time taken in retting to such a point that the wood snaps easily varies with the temperature. Heat is generated during the fermentation and evil-smelling gases are given off. On the fifth or sixth day decomposition has usually gone far enough, and as soon as the fibre pulls readily off the woody core the sheaves are removed. The bundles are rinsed one by one as they are lifted out of the pool and are again placed on end to dry. A silkier feeling is lent to the flax if the retted and dried stems are again stacked for a few weeks before the process of *scutching* begins.

The Courtrai Treatment. Courtrai flax, the most highly prized of any, is retted not in pools but in the slow current of the river Lys, whose water is supposed to be better for retting flax and bleaching textiles than that of any other in the world. The bundles are packed upright in wooden crates made with a solid floor and sides that are open but for the canvas that is stretched round to keep out impurities.

The crates, holding from one to one and a half tons of stems, are launched, when full, into the stream, and weights are laid on them to submerge them. Fermentation sets in, and the liberation of gases gradually raises the crates in the water, and, after a period of four to fifteen days, the package is hauled to the bank. The flax is lifted out and set to dry, and after drying is given a second and sometimes a third immersion. The treatment and the peculiar properties of the water of the Lys give Flemish flax its admired golden colour. The retting is done not by the growers but by flax merchants whose large and continuous experience enables them to deal with material to the best advantage.



THE FLAX PLANT

Breaking, Scutching, and Buffing. The retted flax has then to be converted into linen, or *line*, to use the name by which the fibre is more usually called. The bark or *shive* and the wood or *boon* have to be brought away, and for this purpose the first operation is to pass the straw through a flax *break*. This is a machine with a series of fluted rollers through which the stems are passed. The flutings are of different widths, so that the woody matter shall be broken into small pieces and be removable with as little effort as possible in the succeeding scutching machine. The scutcher consists of a shaft bearing radial arms carrying hardwood blades. The flax straw is fed in *stricks* or handfuls through a slot, and the blades, beating against the straw, knock out and carry back the wood and dust and allow the cleaned flax to fall into a receptacle below. Scutching is followed by *buffing* or finishing, in course of which process the flax is re-cleaned by exactly similar means and is then ready for the hackling which constitutes the first process of manufacture. In course of scutching a certain amount of short fibre is formed, and this is known alternatively as *codilla* or *scutcher's tow*—a different product from the ordinary tow produced in hackling.

The Irish flaxes are known under several district names and sold usually by the stone of 14 lb. The Courtrai flaxes are the yellowish ones retted in the Lys, and these are distinguished from the blue Flemish flax retted in water-holes. The so-called *White Dutch* flaxes are river-retted, but most Dutch flaxes are a dark grey. French flaxes, prepared partly by dew followed by water-retting, are of less consequence than the foregoing. The Russian flaxes are exported principally from Riga, Windau, and Libau. The Russian basis quality is *Riga Crowns* or *Krons*, and this material is graded by the sellers and sold under the mark K. The various grades are indicated by other initials, and between each grade there is a certain standard margin of difference in value. The mark HK means *light crown*; WK, *white crown*; and GK, *grey crown*. The prefix P, as in PK, stands for *picked crown*, and S stands for *superior*. The grades are known by combinations, such as HSPK, or *light, superior, picked crown*. The best of the thirteen crown grades or *bracks* is SWK or *Spanish white crown*.

Next to the *Crowns* are the *Wracks* (or waste flaxes), marked W, and the *Hof Dreibands* (or three bands), marked HD. Thus, GPW represents *grey picked wrack* quality, and SFPHD stands for *superior, fine, picked Hof Dreiband*. The third range of Riga qualities are the ordinary Dreibands, marked D; the prefix L attached to them signifies *Livland* (the source of origin), and S stands for *Slanetz* or dew-retted.

The best flaxes from the Pskoff province are marked R, the initial letter of *Risten* (very highest). Those shipped from Königsberg are graded in the Riga manner, with the addition of M, signifying *Marienburg*. Quality standards were formerly official, and were instituted originally under pressure from British merchants in the time of Peter the Great. They now represent the standards of individual exporters, most of whom are of German nationality, established in the Baltic ports.

Hemp Production. The hemp weaving trade is scarcely separable from the heavy linen trade, but hemp is rather a material for cordage than for textiles. In its practical aspect hemp may be regarded as a coarser flax, and although produced by a different plant there are many points of resemblance between these fibres. Hemp is raised jointly for seed and for fibre, and it also is a bast fibre requiring to be freed by retting.

The producer is a plant of the nettle order, *Cannabis sativa,* which grows best in a mild and humid climate, and resembles flax in making severe drains upon the constituents of the soil. Hemp was formerly grown on a considerable scale in these islands, and is raised still in Russia, Italy, Austria, and France, as well as in China and Japan. The crop is thickly sown when the fibre is intended for spinning, and more sparsely when the bast is only wanted for rope. In the former case the plant is pulled from the ground, as is done with flax. The leaves are removed, and the stalks tied into bundles, when the roots and the tips are cut off with an axe.

Hemp is sent to be retted at once after harvest, as it is believed to yield a whiter colour than if the stalks are allowed to dry. When the fibre has been retted and dried, the stalks are crushed, in France, under a heavy conical roller running over iron plates, with the object of softening the fibre. In France the softened hemp is pulled into three portions, of which only the bottoms are used for making the finer yarn. In Brittany coarse sheeting and shirting are made of hemp, but in this country hemp is seldom used for other fabrics than canvas.

Jute. Both flax and hemp meet with a rival in jute, a fibre introduced into British industry from India some eighty years ago. Jute is not the equal of either of them in strength and durability, and it undergoes deterioration both in damp and sunlight. It is, however, produced cheaply and in great quantity. Over three million acres of land in Bengal, Assam, Bihar, and Orissa are devoted to its cultivation, and a crop of some nine million bales, each of 400 lb., is raised in India. Jute is more woody in nature than flax or hemp, and in its composition cellulose is combined with lignose. Two varieties of the *Corchorus* plant supply the material.

Jute-growing. The crop is sown between March and June, and three or four months later, when the plants begin to flower, they are cut down at the roots. They grow from five to ten feet high, and have a stalk about the thickness of a man's finger. The stems are stacked for three or four days after cutting, during which time the leaves decay and the fibre gains somewhat in strength. The stems are bound into bundles, and are retted for about ten days in pools of water. The bark is pulled off the stalks by hand at the time that these are taken from the water. The fibre under the bark is rinsed and wrung out, and hung upon lines to dry thoroughly. These strips of fibre range from four to seven feet in length. The root ends are chopped off before packing, and are sold as *cuttings* for the manufacture of cordage and the cheapest kinds of jute cloth. Low-class fibre is sold as *rejections,* and is used in part for spinning and in part for papermaking. *Desi,* a dark-coloured jute, is used for sacks, and *Deara* for making ropes.

Centres of Production. The best fibre comes from northern districts of India. *Uttariya* fetches the highest price, although it is less soft than *Deswal,* the second in value. Market prices for jute are quoted for *first marks,* and these marks consist of names or initials set inside geometrical figures. They represent the standard qualities of the principal exporters whose work is carried on at Calcutta and Chittagong. India has virtually a monopoly of jute growing, and about half the crop is manufactured in Indian mills. One variety of jute is grown in the Sudan for the sake of its leaves, which are used as vegetables; and although Sudanese jute fibre has hitherto been harsh in comparison with Indian, a sample grown in the Upper Nile Province has fetched within four per cent. of the value of Calcutta first marks.

Other Fibres. A number of bast and leaf fibres bear the name of hemp, and are valuable for cordage. The *Sunn hemp* of the East Indies, *Mauritius hemp* grown in Ceylon and Queensland, *Bowstring hemp* from the Bahamas, and, in particular, the *New Zealand hemp,* or *Phormium tenax,* are important. Neither these nor *Manila hemp* are true hemps, or in use for spinning.

One bast fibre which has excited attention disproportionate to its commercial importance is ramie, the material from which mantles for incandescent gas lights are generally knitted. This is the produce of nettle plants, chiefly the *Boehmeria tenacissima* and the *B. nivea,* grown largely in China, Japan, the Dutch and British East Indies, but cultivable over a much wider area. The plant is a particularly easy one to grow, and as many as five crops of stalks can be taken from it in one year.

Ramie Fibre or China Grass. Attempts to utilise it mechanically have been made for nearly a century, and have met with only a qualified success. In the East ramie has been used from time immemorial for making delicate *grass cloths,* in which the fibre is not spun, but is pieced end to end together and woven by hand. An alternative name for the material is *China grass,* which name properly signifies hand cleaned and washed fibre. There are insuperable commercial reasons why hand-cleaning should never be practicable on a great scale. The Chinese, who strip the bark and fibre from the stems by hand, scrape the fresh strips with a bamboo knife, and boil the extracted fibre repeatedly in a lye made with plant ashes and water. The operation succeeds in producing a clean and silky fibre, but the output per man is merely two or three pounds a day, and the cost is, of course, prohibitive.

The utilisation of ramie or *Rhea* fibre is complicated by the presence within the stalks of a powerful and insoluble vegetable gum, and this gum is present in the *ribbons* which come upon the European market. These are strips of fibre

with the bark attached, dried and folded, but otherwise in the same condition as when they were torn from the stem upon the plantation. The gum is removed in German manufacturing practice by a noisome process of fermentation, but more generally use has been made of alkalies and hot water to obtain from the matted fibre and bark a clean, spinnable *filasse*. At its best, ramie filasse is of a silky lustre, but this is lost when the fibre is improperly degummed.

The Disadvantages of Ramie. There are, however, reasons for the persistent failure of ramie to assert itself as a commercial success additional to those which reside in the difficulty of degumming. Ramie yarn is calculated to be about eight times stronger than cotton yarn of the same number when tested by a direct pull, but cotton is found to be four times stronger than ramie under twisting strains. Ramie, in other words, is brittle, and threads of it snap at any knot. This characteristic brittleness obstructs the use of ramie as a substitute for flax, as in such articles as tablecloths the fabrics crack in laundering. The fibre is of high specific gravity, and as weight means cost this fact is strongly to its disadvantage. It can be dyed, but the colours fade much more quickly than upon linen or cotton. The material is comparatively inflexible, and it cannot be spun at all to fine counts. Its fibres have poor powers of adhesion, with the result that the ends of the fibres quickly protrude from the yarn. Ramie is inflammable to a degree that makes its employment dangerous for many purposes. Whereas cotton, and the vegetable fibres in general, contract when wet, ramie is almost unaffected by water, and this is to its disadvantage in some circumstances, and the contrary in others.

Ramie Gas Mantles. Weighted with so many congenital defects, ramie is restricted to a limited number of uses, of which the chief one has already been mentioned. Ramie is suitable for making gas mantles because it is, in the first place, absorbent by nature, and thus takes up a good supply of the incandescent minerals; and, in the second place, because the ash left by ramie after burning does not contract, and the gas mantle thus keeps its due place in the flame.

Special hygienic properties are claimed for knitted ramie underwear, and these may justify the higher price that has to be paid for manufactured ramie than for cotton. Cotton can be grown, carried, and spun into yarn for no more than the bare cost of preparing and spinning ramie, and there is not the most distant prospect of ramie ever taking its place.

The Small Returns from Fibres. All the bast fibres are alike in involving the handling of a great bulk of material in order to recover a relatively small weight of fibre. To obtain about five pounds of flax it is necessary to deal with one hundred pounds of green flax straw; in the case of jute the return is even less. A hundred pounds of ramie yields but two or three pounds of fibre, and as the ribbons occupy much room on shipboard, the freight upon them is dear. If fermentation occurs in transit, the fibre is discoloured and worthless. The earlier growths of ramie ribbon are the more desirable, because in the later crops *knots* or breaks in the continuity of the fibre occur at closer intervals and shorten the length of the staple.

Some progress has been made with artificial substitutes for jute, notably in the manufacture of paper yarns suitable for sackcloth, and in some measure also for floor rugs. Yarns made by rolling or spinning flat ribbons of paper into round thread have been produced for about a dozen years. In one system the pulp is taken in a wet condition from the paper-making machine and twisted into thread by an auxiliary. In others, fully manufactured paper, wound upon reels as if for newspaper use, forms the raw material. The reel is slit into ribbons of such width as may be desired, and, after being damped, the coiled paper is passed through eyelets to make the thread round, and so in a condition for weaving.

Yarn from Paper. Sacking woven from paper yarn has interstices through which fine powders carried in the sacks may leak. An improvement has been introduced in a process patented by Claviez for the manufacture of *Textilose*. Before being slit and twisted the paper is covered first with mucilage, and then with short jute or cotton-waste fibre. Such yarn is used either alone or in combination with jute, and its manufacture is carried on in four factories and countries.

There are drawbacks to the use of paper, for paper is heavy in relation to its bulk, and its strength is sapped by wetting. Paper rugs fray and cannot be expected to last for long, and colours dyed on them are not permanent. Paper yarn has been recommended as a backing or stuffing for cheap carpets, in which capacity it would have to compete with jute. Ambitious attempts to introduce paper yarn into tweeds, to make towels for steamship use, uppers for rubber shoes, chair seating, hat bands, tent cloths and knitted coats have met with no conspicuous success.

The Uses of Bast Fibres. The bast fibres are used to manufacture a very wide range of goods. Linen is employed for fine purposes, like the making of handkerchiefs, cloth for covering collars, shirtings, and ornate damasks for the table; for medium purposes like the making of towels, and for heavy, coarse articles like sailcloth, mail bags and tarpaulins, and also for strong sewing threads for bootmaking. Hemp is used alone or in conjunction with linen for making coarse goods. The principal use of jute is to make wrappers for goods in the form of hessian canvas, grain sacks and bags. Most pile carpets have a backing of jute, although this is often called linen; and oilcloths and linoleums are all made upon a jute foundation.

The uses of one fibre overlap the uses of another, and, although linen is used in conjunction with cotton to a considerable extent, the three bast fibres form a set of industries to themselves, separate from the greater cotton and wool trades.

J. A. HUNTER

The Moon and her Orbit. Eclipses of the Sun and Moon. The Tides. The Physical Features of the Moon.

THE STORY OF THE MOON

The earth, like most of the planets, has a satellite, the moon which moves round it in an elliptical orbit, just as the planets move round the sun. Its globe is rather more than one quarter that of the earth n diameter, measuring 2163 miles. It revolves round the earth in an orbit, which, like that of the earth, is an ellipse; but it is not so nearly circular as that of the earth, its eccentricity being about $\frac{1}{18}$. Thus, the actual distance of the moon from the earth varies from about 250,000 miles to 220,000 miles, while the mean distance is 238,840 miles, which is about 60 times the earth's radius.

The moon takes about $27\frac{1}{3}$ days to complete her revolution round the earth; in other words, she makes a complete circuit of the heavens, from a given star back to the same star again, in that time. Her revolution with regard to the sun, however, on which her phases depend, is not completed in this period, because it is complicated by the earth's motion round the sun. This *synodic* period, of which we usually speak as a month, averages about $29\frac{1}{2}$ days, which is the mean period between successive new moons. The *phases* of the moon depend upon the place which she occupies with regard to the sun as seen from the earth, as has already been explained in the case of the planets Mercury and Venus. When the moon lies between the earth and the sun, the dark side is turned to us and the moon is new. When the earth lies between the sun and the moon, we see our satellite fully illuminated, and speak of her as full. Her degrees of illumination vary steadily between these two extremes in the course of every fortnight. Every night the moon bears a different appearance, waxing through one-half of the month and waning through the other half of the month.

If the orbit of the moon lay in the same plane as that of the earth—the plane of the ecliptic—she would pass directly between us and the sun once in every month at the time of new moon, and would then obscure the sun for the length of time which she took to complete her transit. This does occasionally happen, and the consequent blotting out of the sun for a few minutes is known as a *solar eclipse*. Similarly, when the moon was full, the earth would lie in a straight line between her and the sun, and the earth's shadow would blot the moon out of sight by depriving her of the illumination by which alone she becomes visible. This also happens occasionally, and the result is a *lunar eclipse*. But, as a matter of fact, the moon's orbit does not lie in the same plane with that of the earth, but is inclined to it at an angle of about 5°. Consequently, the moon, when lying in the same direction as the sun, is usually a little above or below our luminary, and there is no eclipse.

A solar eclipse can only take place, in fact, when the moon lies in the direction of the sun, or is new, near the moment at which she passes the *node*, or point at which her orbit intersects the plane of the ecliptic, which hence derives its name. The same is true of the lunar eclipse, which only occurs when the moon is close to one of her nodes at the time of being full, and, consequently, passes into the shadow of the earth. It follows from geometrical considerations that there cannot be less than two or more than seven eclipses in a year, of which at least two must be solar. From the computed motions of the earth and moon we find that the conditions which determine eclipses repeat themselves with great exactness after a period of about 18 years and 11 days. This recurrence of eclipses was discovered from observations by the Chaldeans, who named this period the *Saros*, and were enabled to predict coming eclipses by its use.

There is a distinction between solar and lunar eclipses, which depends upon the relative movements of the earth and the moon. A lunar eclipse is visible from all parts of the earth where the moon is above the horizon; and a moment's thought will show us that this must be so, because an eclipse of the moon is due to the moon entering into the shadow of the earth, and is exactly comparable to switching off an electric light, Wherever the moon can

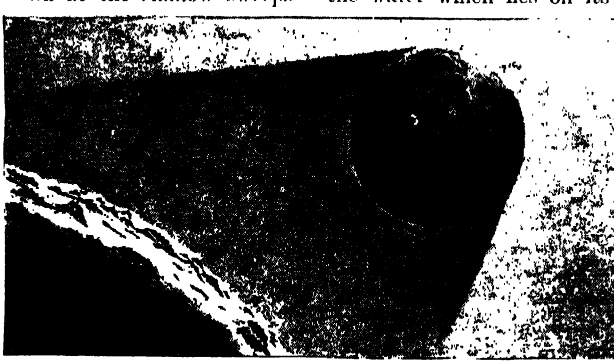
be seen at all—even from Mars—it will be eclipsed. But this is not at all the case with a solar eclipse, which only exists for observers who occupy a narrow belt of the earth's surface. A solar eclipse simply means that the moon passes between us and the sun, and that the earth itself lies for a few minutes in the shadow of its satellite. Now, everybody knows that the breadth of a shadow depends upon the relative size and distance of the object which casts it. The sun is incomparably larger than either the earth or the moon, and, consequently, the shadows which they cast are both conical, like the point of a pencil tapering off to an abrupt end.

The Duration of Totality. The earth's shadow is much longer than the moon's, in exact proportion to the relative size of the two bodies. Thus the moon takes a considerable time to pass through the earth's shadow, and may be totally eclipsed for as much as two hours. But the moon's shadow is only just long enough to reach the earth at all. The largest possible cross-section of the moon's shadow where it reaches the earth's surface is about 168 miles; and as the shadow sweeps across the earth from west to east, it is only observers situated within a belt no wider than this who will see the sun *totally* eclipsed. Outside this belt a *partial* eclipse will be visible over a very much greater area, its size decreasing as the distance from the belt of totality increases. The width of the eclipse-belt, and the consequent duration of totality, vary between wide limits with the distance of the moon from the earth at the moment of eclipse. The moon's apparent size is very nearly that of the sun, each being a little over 30 minutes in diameter. But these both vary with the distance of the earth from the sun and moon, and it sometimes happens that at the time of an eclipse the moon is so far away that its shadow does not quite reach the earth, and its apparent diameter is rather less than that of the sun. At such a time we see an *annular* eclipse, in which at the moment of greatest eclipse a bright ring of the sun's disc is still visible surrounding the moon. It was on observations made during the brief duration of total eclipses of the sun that astronomers long depended for their chief knowledge of the solar constitution, and that they are still dependent for their study of the corona.

DIAGRAM OF A SOLAR ECLIPSE, SHOWING THE UMBRA AND PENUMBRA SHADOWS

The Moon and the Tides. The gravitational attraction of the moon has a very important influence on the earth in causing *tides* in the sea. The way in which these tides are caused will be easily understood from a glance at the diagrams on page 424.

We have seen that the attraction of one body for another varies inversely as the square of its distance. As the waters of the sea on the side of the earth nearest the moon are nearer our satellite than the centre of the earth, the moon pulls these waters toward her with greater force than she exercises upon the body of the earth; and as they are quite free to move, they are consequently heaped up in a kind of watery mound, which is highest on the spot vertically beneath the moon. In exactly the same way the moon attracts the earth more powerfully than the water which lies on its opposite side, and so draws the earth away from that water, which is consequently heaped up into a similar mound on the point exactly opposite. Thus we have two simultaneous high tides, culminating at the two points of the earth which lie in a straight line with the moon, and, consequently—because the total amount of water in the seas does not vary—correspondingly low tides at two points on the earth distant by 90° from these.



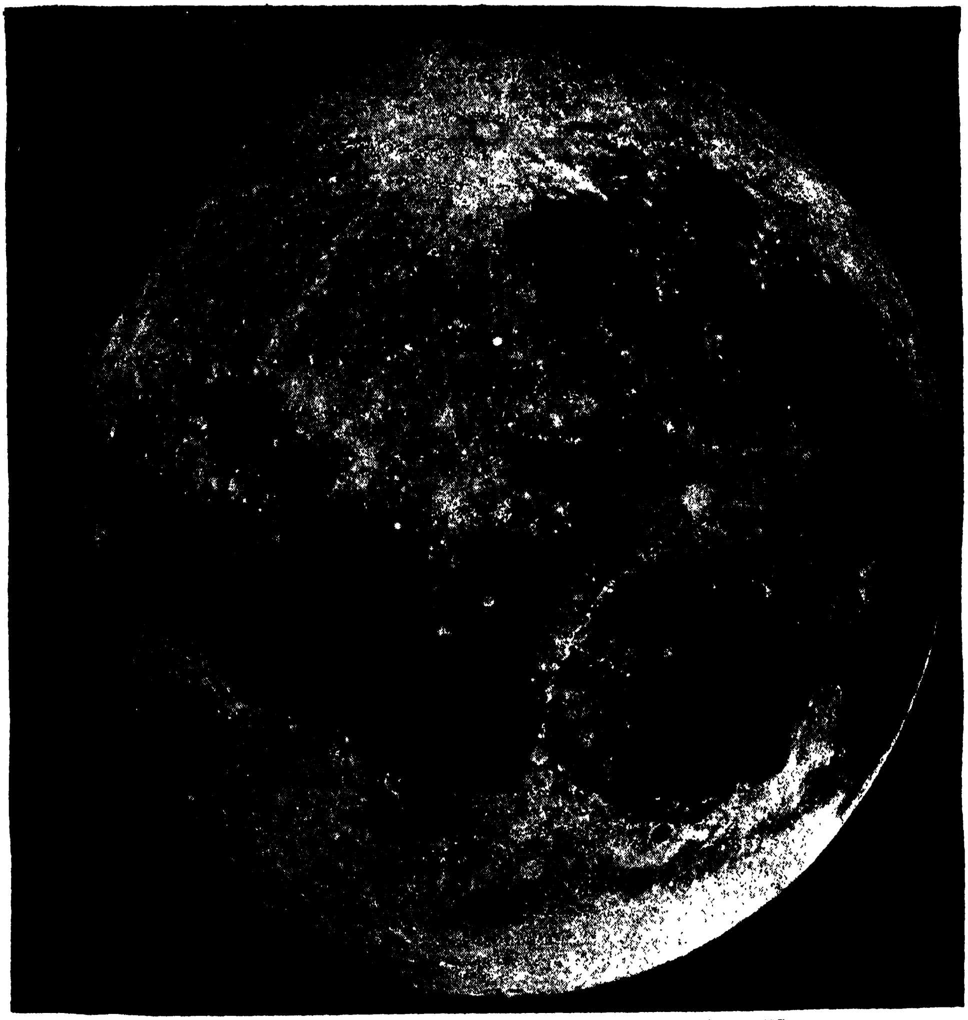
A LUNAR ECLIPSE AS SEEN FROM THE MOON

If the moon were fixed with regard to the earth, the tide would always be high at one set of places and low at another, but as the earth completes a rotation in twenty-four hours, while the moon holds its accumulations of water in the same place, the high tide and low tide traverse every part of the seas, there being two high and two low tides at each place daily. If the earth were a perfect sphere, uniformly covered with water, this state of things would be actually observed by its fishy inhabitants. But the

configuration of its surface greatly complicates the actual motion of the tides, which are greater or less, sooner or later, according to the shape of the coast line, as is explained in GEOGRAPHY.

Spring and Neap Tides. The sun as well as the moon helps to create tides in our seas. Its mass is very much greater than that of our satellite, but so is its distance, and consequently the solar tide is only about two-fifths as high as that caused by the moon. When the sun and the moon lie nearly in the same straight line with the earth, and the moon is new or full, the solar and lunar tides help one another, and we have extra high tides, known as *spring tides.* When the sun and moon lie at right angles to one another with regard to the earth, and the moon is in its first or last quarter, their tidal forces are opposed, and moderate or *neap tides* result. It will readily be seen that the average height of the spring tide should be rather more than double that of the neap tide at any particular place.

How the Day has Lengthened. One very interesting effect of tides, as the late Sir George Darwin showed, is to act as a brake upon the rotation of the earth. We have just seen that while the earth rotates a great mass of water is held still by the attraction of the sun and moon. This acts exactly like the brake which is used on the axle of a wheel, and by its friction tends to diminish the rate at which the earth rotates. In the early days of the earth this effect was much more considerable than it is at present, and Sir George Darwin has shown that tidal friction has lengthened the day from about three hours to its present length, and that the moon itself almost certainly once formed part of our planet and was thrown off from it by the centrifugal force due to this extremely rapid rotation. When the earth was still in a liquid condition, tides were caused in its actual substance by the attraction of the sun, and afterwards possibly of the moon, and the retarding effect of these gigantic tides, which



THE MOON, SHOWING THE DARK PLAINS AND BRIGHT STREAKS

This photograph was taken at Lick Observatory, and that on page 1024 at the Yerkes Observatory

may have risen as much as 600 miles in height, must have been immensely great. At present there is ground for believing that the tidal friction is still exerting a retarding influence on the earth's rotation; but this influence is exceedingly small, and it is practically certain that the length of the day has not varied by so much as one-hundredth of a second since the dawn of astronomy 2000 years ago.

The Physical Condition of the Moon. As we have seen that the moon was originally a fragment drawn away from the earth, it is only reasonable to suppose that it is composed of the same materials. But it differs from the earth in one very important respect. Being so much smaller, it has cooled more quickly, and has probably passed through all the stages of planetary life, in the midst of which the earth is now.

Few things are more certain than that the moon is a dead world. It has no atmosphere, so far as we know, and if one exists it must be more rare than the vacuum inside the incandescent electric lamp. Such air and water as the moon must once have possessed have been absorbed into its substance or flown away into space. One consequence of its denuded condition is that the surface of the moon must undergo extremes of heat and cold. The side on which the sun is shining must be far hotter than the tropical regions of the earth, while the other side must endure the cold of empty space, which is very near the absolute zero of temperature. It is hardly necessary to add that the moon cannot be the abode of any kind of life which we can conceive as possible. Life may once have existed there, but it is long extinct.

THE CRATER OF COPERNICUS, FIFTY MILES IN DIAMETER

The Face of the Moon. The moon is a globe about 2163 miles in diameter, and its mass is about $\frac{1}{81.5}$ of the mass of the earth. Its density is about 3·4, that of water being taken as unity. The moon rotates on its axis in 27 days $7\frac{3}{4}$ hours, so that its day and night are each a fortnight in length. This period is the same as that in which it revolves round the earth. The moon, consequently, always presents the same face to the earth—though, as a matter of fact, we are able to see rather more than a single hemisphere of the moon because of an oscillating motion of our satellite known as *libration*.

But there is a considerable portion of the moon's surface, amounting to more than three-eighths of the whole, which is permanently invisible to the observer. Novelists have allowed their imagination to run riot about this invisible side of the moon, and have provided it with an atmosphere, flowing water, and inhabitants. But it is as certain as anything of the kind can be that the invisible half of the moon is perfectly similar to that which we see.

The Craters of the Moon. The chief feature of the moon's visible surface is the numerous and often gigantic craters with which it is pitted. These objects, when observed through a telescope, or even a powerful field-glass, have a striking resemblance to volcanic craters on the earth. They are, indeed, on a vastly greater scale, some of them being more than 100 miles in diameter. But there is little doubt that they are the remains of extinct volcanoes which once covered the moon with violent and long-continued eruptions. Probably the surface of the earth was once in a similar condition, but the existence of the various denuding agencies which our planet possesses have entirely changed the configuration of its surface [see GEOLOGY]. No distinct evidence of volcanic activity has been seen upon the moon in modern times, though a few observers believe that they have noticed very slight changes of this nature in progress. It is most probable that the moon is a dead world, affording a kind of prophecy of what the earth will be one day, when it also pursues a frozen and lifeless journey through space.

Selenography. The surface of the moon has been studied and mapped on a large scale. Its chief features are three in number: (1) the numerous *volcanic craters*, such as Tycho and Copernicus, which are mostly named after distinguished men of science; (2) the wide, dark plains which are known as *seas*, because they were formerly thought to consist of water; (3) the curious systems of *bright streaks*, which radiate from many of these craters, of which the most remarkable extend in all directions from the great crater Tycho, near the moon's south pole, and are conspicuous even to the naked eye at the time of full moon. The student will find the names and description of these various features of lunar topography—*selenography*—in any good textbook of astronomy.

W. E. GARRETT FISHER

The Principles of Several Types of Levers: Wheels and Axles, Pulleys, Inclined Planes, Wedges and Screws.

ELEMENTS OF MACHINES

A MACHINE, no matter of what nature or how complicated it may be, is an instrument by which force applied at one point is transferred to another point, being at the same time intensified or changed in direction. This modified force has always to overcome some resistance, as that of gravity, friction, or the cohesion of particles of matter. This resistance in mechanics is denoted by the term *weight* (W), and the force applied to overcome it is termed *power* (P). In statics, the problem is to find the magnitude of P acting at one point necessary to balance W at another point; it is generally supposed, however, that P is sufficient to set a machine in motion. When the weight (W) is greater than the power (P), the machine is said to work at a *mechanical advantage*, the ratio being shown by the fraction $\frac{W}{P}$. But if this fraction is not greater than unity—that is, if W is less than P in magnitude—the machine works at a *mechanical disadvantage*.

The elements of the most complex machine are reducible to what are called the *six mechanical powers*: (1) the lever; (2) the wheel and axle; (3) the pulley; (4) the inclined plane; (5) the wedge; (6) the screw.

A *lever* is a rigid rod free to turn about a fixed point called the *fulcrum*. Levers are divided into three classes according to the relative positions of the power, fulcrum, and weight. Thus they may be placed in the order PFW, PWF, or WPF [**1** - **3**]. The condition for equilibrium in a lever of any of these three classes is that the movement [Fig. **30**, page 387] of the power round the fulcrum be equal and opposite to that of the weight. Therefore P, multiplied by its arm (AC) = W, multiplied by its arm (BC). That is, $\frac{W}{P} = \frac{AC}{BC}$.

Levers of the First Class [**1**]. Remembering what has been said above concerning mechanical advantage, it is clear that levers of this first group will be only mechanically advantageous when AC is greater than BC, so that the fraction shall be greater than unity. If the arm BC is longer than AC, the lever will be mechanically disadvantageous, the effort being greater than the weight required to be raised. The effort will be equal to the weight when AC = BC, and the fraction equals unity. Common examples of the first class of lever are the poker, the handle of a pump, see-saw, crowbar (when it rests on a block in front of the weight being raised), and a canal lock-gate. Scissors form a double lever of the first class.

Levers of the Second Class [**2**]. Here AC is always greater than BC, and there is, therefore, always a mechanical advantage. The crowbar—when one end rests on the ground—and the wheelbarrow are everyday examples of levers of the second class. Nutcrackers are a double lever of this type.

Levers of the Third Class [**3**]. In this class, AC is always less than BC, which means that $\frac{AC}{BC}$, or $\frac{W}{P}$ is less than unity, and so levers of the third class are always disadvantageous as regards power. Nevertheless, they are useful where speed and range of movement are required. For example, if ACW [**4**] represent a man's arm bent at the elbow, the hand holding a weight (W), it is evident that the contraction of the muscle through the small arc at P will cause the weight to move through the relatively much greater arc shown by the dotted line from W. A fishing-rod, the treadle of a turning-lathe, a whip, and the fore-arm as mentioned above, are all levers of the third class, tongs being a double lever of the same kind.

Wheel and Axle. The second mechanical power, *the wheel and axle*, is merely a modification of the lever. It consists [**5**] of two cylinders turning on a common axis. The larger cylinder is conventionally called the wheel, the smaller one the axle. Ropes are coiled round both wheel and axle, but in opposite directions, so that as the rope round one unwinds, that round the other winds up. Looking at the end section in the illustration, the principle of the lever will be immediately observed. The power and the weight act at the points A and B, where for the moment the two ropes are tangents to the two circles, and the conditions for equilibrium for the ordinary lever hold good in the wheel and axle—namely, P × AC = W × BC; or $\frac{W}{P} = \frac{AC}{BC}$; *i.e.*, $\frac{W}{P} = \frac{\text{Radius of wheel}}{\text{Radius of axle}}$, and since the circumference of a circle is proportional to its radius, the conditions of equilibrium are reduced to $\frac{W}{P} = \frac{\text{Circum. of wheel}}{\text{Circum. of axle}}$. From which it follows that a big wheel and a small axle will give greater mechanical advantage than when the diameters more nearly approach each other. The capstan, windlass, rack and pinion, and toothed wheels in general, are common examples of the principle of the lever, or wheel and axle.

Pulleys. The *pulley* is a wheel whose circumference is grooved to prevent the rope —called the tackle—which passes round it from slipping off; the wheel turns freely on an axis through its centre, and is fixed in a framework called the pulley-block, or sheave. Sometimes this pulley-block is fixed **to a**

beam, or rafter for example; sometimes it is movable, as on a crane, and sometimes a series of pulleys are arranged in a particular combination.

The *fixed pulley* [6] gives no mechanical advantage, the weight on one string requiring to be balanced by an equal weight on the other. It is useful, however, in changing the direction of a force, so that by pulling down, or horizontally, a weight may be raised vertically.

Movable Pulleys. The single *movable pulley* is shown in 7. The weight (W) being supported by two cords, the tension on each is evidently ½ W, but as one cord is attached at A to the beam, the force or weight P has only to support ½ W, or $\frac{W}{2}$. Thus $P = \frac{W}{2}$; *i.e.*, $\frac{W}{P} = 2$, or the mechanical advantage in a single movable pulley = 2. In other words, the weight is twice the power—1 lb. being able to support 2 lb. To obtain this advantage, however, the strings must be parallel.

A still greater advantage is gained when several movable pulleys are combined to raise a weight. The three methods of combining movable pulleys are spoken of as the first, second, and third systems.

Separate-string System. In the first, or separate-string system [8] each pulley hangs by a separate cord; one end is fastened to a beam or other support, and after passing round a pulley the cord is attached to the block of the one above it; the last cord, however, passes round the fixed pulley and supports the counterpoise (P), the weight (W) being attached to the lowest pulley.

It is necessary to suppose in all theoretical questions concerning pulleys that the ropes or cords are perfectly flexible and that friction is absent. Then it follows that *the tension of the rope is the same in every part* irrespective of the number of pulleys in the combination. As a matter of fact, however, these two theoretical conditions are very far from being present in practical work, and though in theory the greater the number of pulleys in any system the greater would be the mechanical advantage, the enormous amount of friction and the lack of flexibility of cord render a multiplication of pulleys impossible.

In 8 it is clear that the tensions on the strings marked 1 are equal, as in the case of the single movable pulley, so that P supports a weight equal to 2P on the first pulley-block (A). Hence the tension on the string below A equals 2P, and so the pulley B supports a weight 4P (2^2P). In the same way C supports a weight 8P (2^3P), and so on, each successive block doubling the mechanical advantage. With three pulleys, therefore, $W = 2^3P$; with four pulleys, $W = 2^4P$; with any number of pulleys conveniently represented by the letter *n*, $W = 2^nP$, *i.e.*, $\frac{W}{P} = 2^n$. Thus the mechanical advantage in the first system $= 2^n$.

Single-string System. In the second, or *single-string system* [9] the pulleys are contained in two blocks, the upper one fixed, the lower one movable, the weight being attached to the latter. The same string passes round all the pulleys as shown in the diagram. Here the tension throughout the string equals P, and as there are four (practically) vertical strings supporting the lower block, the weight W is supported by four upward forces, each equal to P. Therefore W = 4P. If there are *n* pulleys, then $W = nP$; *i.e.*, $\frac{W}{P} = n$. Thus the mechanical advantage in the second system = *n*.

The Third System. The third system is really the first system turned upside down, as in 10, the end of each string being attached to a bar carrying the weight. The tensions supporting the weight here are P + 2P + 4P. Thus W = 7P, or $W = (2^3 - 1)P$, the index of the figure 2 representing the number of pulleys. With four pulleys $W = (2^4 - 1)P = (16 - 1)P = 15P$. With *n* pulleys, $W = (2^n - 1)P$; *i.e.*, $\frac{W}{P} = 2^n - 1$. Thus the mechanical advantage in the third system $= 2^n - 1$. It must be noted, however, that in this system the weights of the pulleys assist the power instead of acting against it, as in the other two systems.

The Inclined Plane. The inclined plane permits of the raising of a body to a particular height by exerting a smaller force through a greater distance. The directions in which a force may be applied to a body on an inclined plane are: (1) *horizontally*; (2) *parallel to the plane*.

In 11, which represents a section of an inclined plane, the force acts parallel to the plane. Three forces combine to keep the body in equilibrium: (1) the weight (W) acting vertically downwards; (2) the reaction or resistance (R) of the plane acting perpendicularly to the plane; (3) the pull or power (P) acting up the plane. (The surface of an inclined plane is theoretically perfectly smooth and free from friction, and by the reaction (R) is meant the resistance of the plane to bending, breaking, or penetration. Hence the force R acts perpendicularly to the surface.) It can then be shown by the Triangle of Forces that $\frac{P}{BC} = \frac{R}{AC} = \frac{W}{AB}$. That is, $\frac{P}{\text{Height of plane}} = \frac{R}{\text{Base of plane}} = \frac{W}{\text{Length of plane}}$. Therefore the pull required may be found from the equation $P = W \times \frac{\text{Height of plane}}{\text{Length of plane}}$, and the resistance $R = W \times \frac{\text{Base of plane}}{\text{Length of plane}}$. The mechanical advantage of the inclined plane $= \frac{W}{P} = \frac{\text{Length}}{\text{Height}}$; in other words, the greater the incline in a road or railway the greater is the pull required.

Pulls and Gradients. On a gradient of 3 in 10 a weight of 160 lb. could be pulled by a force slightly greater than 48 lb. If, however, the gradient were but 3 in 16 the force necessary

would be scarcely more than 30 lb. The weight would therefore be raised to the same height with a less force; but it must be remembered that as this force acts through a greater distance no work is saved. Whatever be the gradient, the work done by P acting along the plane is always equal to the work which would be done in raising the load W vertically from C to B. That is, $P \times AB = W \times BC$, or, as we have just seen,

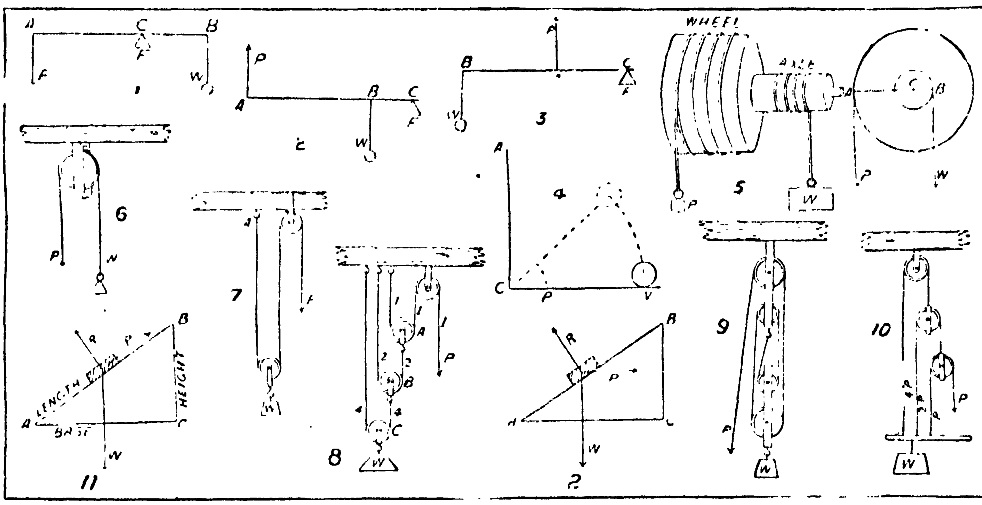
$$\frac{W}{P} = \frac{AB}{BC} = \frac{\text{Length}}{\text{Height}}.$$

When the force is applied horizontally, as in **12**, then the ratio between the forces keeping the body in equilibrium is $\frac{P}{\text{Height of plane}}$, $\frac{R}{\text{Length of plane}}$, $\frac{W}{\text{Base of plane}}$. Then $= W \times \frac{\text{Height of plane}}{\text{Base of plane}}$, and the resistance,

penetrating instruments. A wedge whose section is an isosceles triangle is the commonest and most advantageous form. The force is applied at the back of the wedge (AB), and the resistance on each side may be considered to act at right angles to the slant edges of the wedge.

Owing to the fact that the power applied to AB is not a continued pressure but a series of impulsive forces, the theory of the wedge is less exact than that of the other mechanical powers. Considering the power and the resistance on each side, however, as three forces in equilibrium, it may be demonstrated that the resistance $R = P \times \frac{\text{Length of an equal side}}{\text{Back of wedge}}$.

Then the mechanical advantage will be $\frac{R}{P} = \frac{\text{Length of equal side}}{\text{Back of wedge}}$. So that by diminishing the size of the back and increasing the length of



APPLICATIONS OF MECHANICAL POWER

$R = W \times \frac{\text{Length of plane}}{\text{Base of plane}}$. Also $\frac{W}{P} = \frac{\text{Base}}{\text{Height}}$. Considering this second case from the point of view of work done, since P acts in the direction AC, then $P \times AC$ = work done by P. Also the work done by raising the load W vertically through $CB = W \times BC$. And $P \times AC = W \times BC$; *i.e.*, $\frac{W}{P} = \frac{AC}{BC} = \frac{\text{Base}}{\text{Height}}$. Again, in **11**, since each force is proportional to the side to which it is perpendicular—*i.e.*, P, R, W are proportional to the height, base, and length respectively—and since $AB^2 = AC^2 + BC^2$ (Euc. I. 47), therefore $W^2 = P^2 + R^2$. In the case where the force applied is horizontal, $AC^2 = AB^2 - BC^2$; that is, $W^2 = R^2 - P^2$.

The Wedge. The *wedge* [**14**] is a block tapering to a thin edge, a double inclined plane as it were. It is used for splitting wood or other material, and for raising heavy bodies, as in the raising of a ship in a dry dock by inserting wedges under the keel. Common examples of wedges are knives, chisels, swords, axes, plugs, planes, needles and pins, nails, and all cutting and

the side—that is, diminishing the angle of penetration—the mechanical power of the wedge is increased.

The Screw. The *screw* is the last of the mechanical powers, and, like the wedge, is derived from the inclined plane. It consists of a cylinder, on whose surface is a spiral ridge called the *thread.* The relation between the thread and the inclined plane is easily seen by cutting out a right-angled triangle of paper, corresponding to the section of an inclined plane. If this be wrapped round a rod—say, a round ruler—the hypotenuse of the triangle forms the screw thread, or *helix,* the base of the triangle (or plane) corresponds with the circumference of the cylinder, and the height will be the distance between the threads, or the *step* of the screw, technically known as the *pitch.* The threads are sometimes square in section (square screws), sometimes acute (sharp or vee screws). The screw works in a fixed *collar* or *nut,* which is a hollow cylinder, whose internal surface carries a groove, or internal thread, in which the screw thread fits.

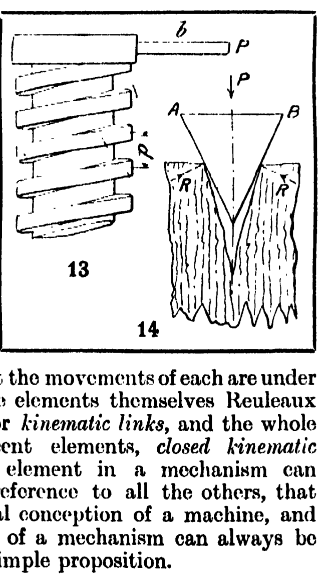
The ordinary copying-press illustrates the method of using the screw. Power is applied by means of a lever (the arm or handle of the press) attached to the end of the screw. The screw then moves forward in the direction of its axis, overcoming resistance. Or, as in the case of the screw-jack, it may be used to raise a weight.

In finding the relation between the force applied and the resistance which is overcome, it is important to note that every time the screw performs a complete revolution it moves forward through a distance equal to the space between one thread and the next. If, in **13**, power (P) be applied so that the arm b makes a complete revolution, the work done will be equal to P multiplied by the circumference of the circle of which b is the radius—that is, $P \times 2\pi b$. At the same time, the work (W) done by the screw in moving through the distance p (the space between two threads) equals $W \times P$. Then $P \times 2\pi b = W \times P$. And the mechanical advantage is:

$$\frac{W}{P} = \frac{2\pi b}{p} = \frac{\text{Circum. of circle described by lever.}}{\text{Pitch, or step, of the screw.}}$$

Thus the mechanical advantage is increased by diminishing the pitch, or by increasing the length of the arm or lever to which the power is applied.

Constraint. If we now look further into these examples, we find that the feature of constraint is an essential one. The elements are all paired together in such a way that they can only move in certain relations, and each pair of elements is paired with others adjacent, so that the movements of each are under constraint. The elements themselves Reuleaux termed *links*, or *kinematic links*, and the whole series of adjacent elements, *closed kinematic chains*. As no element in a mechanism can move without reference to all the others, that is a fundamental conception of a machine, and the workability of a mechanism can always be tested by this simple proposition.



13

14

In the levers the fulcrum must be fixed and incapable of movement, and the arms must be free to turn around the fulcrum as a centre. In the wheel-and-pulley systems the centres of certain pulleys are fixed, others are movable. The movement of the "cord" is constrained to one direction. The sliding movements of the load on an inclined plane, that of the wedge, and that of a nut in its screw, are also constrained. In fact, it would be impossible to conceive of a mechanism from which the condition should be absent.

But in speaking of kinematic links and chains we must not be understood to use the term in its literal sense. Links are often non-rigid. A cord, a belt, a spring, or even a pressure fluid, as water, gas, steam, is as truly a link as a bar of steel is. All depends on its application and its relation to other rigid parts. Tension and compression elements are alike links. By the use of springs, for example, a mechanism is often prevented from knocking itself to pieces. Yet the movements of the mechanism are as surely accomplished under the constraint of the elastic spring as though it were a non-elastic bar. So with the cords, ropes, chains, or pulley systems. Flexibility is essential, yet the connections and the relative movements are assured.

Link-work. Mechanisms and machines are now regarded as being built up of link-work, comprising combinations of bodies and elements, termed kinematic links and chains, and arranged as turning or sliding pairs. The distinction between a mechanism and a machine is, then, that between the elementary combinations, and the complete embodiment of these in a fixed base or standard which is a static body only, and a convenient means of support and attachment to the kinematic links and chains.

Elements. We next consider the meaning of what are termed *elements*, the name given to two pieces by which motion is so constrained as to render all other motions impossible, an absolute essential in machine design. This is done in numerous ways, but it is usual to classify all such devices under either one of two heads. First, they form either *turning* or *sliding pairs*, the first being represented by the rotation of a shaft or pin in its journal or bearing, the second by the movement of an engine slipper-block between its guides, or of a die in a slot link; the first is a movement of revolution, the second one of translation. In both cases the movement is constrained to take place in directions only in one plane, and not at all in a direction perpendicular thereto.

A second classification is that into *lower* and *higher* pairs of elements, the first-named denoting a point contact only, the second a surface contact. The last-named is that which is almost universally employed in machinery, because of its greater durability. That of the higher pair, or surface contact, is only possible in plane motion, or movements of revolution, and sliding.

We recognise in the levers examples of the turning pairs of Reuleaux; in the inclined plane and wedge, sliding pairs; and in the screw, twisting pairs, or a movement of translation in a helical plane around an axis. The lever and the inclined plane, therefore, include all essential mechanical motions, no matter how they are disguised in a thousand-and-one mechanisms.

Centres. The simple movements of bodies are referable to a centre, or point, or axis. This is obvious enough in the case of a rotating wheel. But it is convenient to assume the same thing in all motions—those of translation as of rotation—only in the first-named the centre is movable in space, and is often imagined to be situated at an infinite distance away. This is in harmony with the assumption of the mathematician that

a straight line is an arc with a centre at infinite distance. It simplifies calculations and leads to no error.

When a body has a movement of translation its supposed centre is then denoted an *instantaneous centre,* because its position changes instantly, a term, however, which has a wider application, to be seen presently. This assumption then covers all cases that can arise, including those in which a circle arc exists of immense radius, because the flattest arc must have a centre somewhere at a finite distance. These two movements, therefore—that of rotation and that of translation—include all movements that can exist. But these movements around a centre or axis may be complicated. Fortunately, nearly all those with which the mechanician has to deal occur in one plane, for which calculations are much simplified. When motions perpendicular or in oblique relation to a plane surface occur, they introduce other problems.

Instantaneous Centre. The difference between the instantaneous and a fixed centre is that the first-named changes its position contantly, while the latter is fixed. The virtual centre is explained by the relative motion of two rigidly constrained elements in a mechanism, the relative motion of which is unalterable, just as is that of the rim of a wheel moving round its axle, or a ball twirled at the end of a string held in the fingers. The relative positions of the body and its centre do not change with the rotation of the wheel or the ball in space. So, too, though the instantaneous centre of a moving body moves, it occupies a fixed relative position toward the *point path* of the moving body, or the essential points in that path; and the relative positions of the moving point and the virtual centre are determined by the distance between them, fixed rigidly by the connecting link of metal, or other material of the mechanism.

The instantaneous centre has no necessary relation to the *shape* of the point path, or path traced by the moving body. That may be straight, or a circle arc, or be of irregular shape. The essential fact is that any body moving in any path is at every successive instant moving tangentially to a line that connects its movement, rotational for an instant, with a centre of motion for that instant. And this movement, whatever the ultimate form of the point path delineated, coincides for each successive instant with that of a figure rotating round a centre.

Several results of a practical character follow. As the point path lies at any instant tangentially to the virtual radius, all virtual radii for successive positions must pass through the virtual centre. The only case in which the virtual centre is at an infinite distance is that of two point paths moving in parallel lines.

An advantage of approaching the study of mechanics in this way is that principles are simplified. The fixed or permanent centre of a rotating wheel or axle becomes practically identical in its study with the instantaneous centre; often the two coincide absolutely.

Centrode. As the virtual centres change instantly in the general case of non-rotating bodies, they trace a path in their successive positions. This is termed the centrode, and the surface or locus of the virtual axis is termed the axode.

Unless we approach the study of applied mechanics on the lines indicated in the foregoing paragraphs, it is not possible to grasp the similar fundamental principles which underlie many mechanisms that have not even a superficial resemblance to each other; nor, on the other hand, is it easy to distinguish others which appear superficially to belong to the same group. The theoretical and the practical are thus found constantly overlapping, and in the practical is always included the question of cost, both of material and labour, a factor which may be neglected by the mathematician, but not by the designer of machinery, and this is often why one device is adopted in preference to another.

Applications of Power in Practice. Going a stage farther, the engineer sees in the diagrams we have discussed only the skeleton outlines which denote principles. Looking beyond them, he recognises a hundred mechanisms which clothe the bare anatomy with living forms. The fulcrum in the lever group does actually occur in the triangular form shown, in the knife edges of weighbridges and balances. But most often it is the cylindrical pivot of a beam or a rocking lever, or of a derricking crane-jib, or the crank-pin of an engine, or the shafts of wheels. The gaunt lines become disguised in the strong arms and ribs of pulleys, of toothed wheels, of engine-beams. The crude wheel and axle appear in some pulley-block designs, but the "axle" much more often occurs in the disguised form of the chain-drums of cranes; while the "wheel" is recognisable in the winch-handle, or the large driving wheel on the drum-shaft.

The fixed pulley is found at the head of all crane-jibs and elsewhere. Movable pulleys occur in pulley-blocks of divers forms, arranged in more workable designs than those used for diagram purposes, while the friction which is so excessive in these is turned to account in the self-sustaining or differential type. The inclined plane is utilised in keel-blocks for ships, in inclined tracks for mines, and for heaving up slips for vessels. The wedge appears in various forms of friction clutches for the driving and release of shafting, in cottars and keys for uniting lengths of rod, and fastening wheels to shafts, and generally for making metal connections that can be rapidly made and broken.

The inclined plane in the form of the screw is perhaps used to a larger extent than any other single element of mechanism. It becomes a means of connection and union, temporary or permanent; a device for producing end-long movement, a mechanism in combination with the lever for gaining almost unlimited power, a device for imparting linear movement to materials, as in conveyors, a method of measurement, the agent for the propulsion of the biggest liners and battleships.

Often mechanisms are so changed that their essential elements are disguised.

JOSEPH G. HORNER

A Third Lesson in Spanish and further Lessons in the Courses of Latin and French

LATIN

Continued from page 783

By Gerald K. Hibbert, M.A.

Section I. GRAMMAR.

Anomalous Verbs are verbs that do not form all their parts according to rule. The following are the most common:

Possum (*Pote sum*) = I am able; *Volo* = I wish; *Nolo* (*Ne-volo*) = I am unwilling; *Malo* (*Magis-volo*) = I prefer; *Fero* = I bear; *Fio* = I am made, I become (used as the passive of *Facio*, I make); *Eo* = I go; *Queo* and *Nequeo* = I can and I cannot; *Edo* = I eat.

Scheme of Conjugation.

Indicative Mood.

Present.

	Singular.	*Plural.*
1.	possum	possumus
2.	potes	potestis
3.	potest	possunt
1.	volo	volumus
2.	vis	vultis
3.	vult	volunt
1.	nolo	nolumus
2.	nonvis	nonvultis
3.	nonvult	nolunt
1.	malo	malumus
2.	mavis	mavultis
3.	mavult	malunt
1.	fero	ferimus
2.	fers	fertis
3.	fert	ferunt
1.	fio	—
2.	fis	—
3.	fit	fiunt
1.	eo	imus
2.	is	itis
3.	it	eunt

Future Simple.

Pot-	.. ero	eris	erit	erimus	eritis	erunt
Vol- Nol- Mal- Fer- Fi-	am	es	et	emus	etis	ent
I-	.. bo	bis	bit	bimus	bitis	bunt

Imperfect.

Pot-	.. eram	eras	erat	eramus	eratis	erant
Vole- Nole- Male- Fere- Fie- I-	bam	bas	bat	bamus	batis	bant

Perfect, Future Perfect, and Pluperfect.

Potu- Volu- Nolu- Malu- Tul- —— Iv-	1. i	isti	it	imus	istis	erunt *or* ērĕ
	2. ero	eris	erit	erimus	eritis	erint
	3. eram	eras	erat	eramus	eratis	erant

Subjunctive Mood.

Present.

Poss- Vel- Nol- Mal-	im	is	it	imus	itis	int
Fer- Fi- E-	am	as	at	amus	atis	ant

Imperfect.

Poss- Vell- Noll- Mall- Ferr- Fier- Ir-	em	es	et	emus	etis	ent

Perfect and Pluperfect.

Potu- Volu- Nolu- Malu- Tul- —— Iv-	1. erim	eris	erit	erimus	eritis	erint
	2. issem	isses	isset	issemus	issetis	issent

Imperative Mood.

Possum, Volo, Malo, have none.

Present.		*Future.*		
2nd Sing.	*2nd Pl.*	*2nd Sing.*	*2nd Pl.*	*3rd Pl.*
noli	nolite	nolito	nolitote	nolunto
fer	ferte	ferto	fertote	ferunto
fi	fite	—	—	—
i	ite	ito	itote	eunto

Infinitive Mood.

Present.	*Pres. ptc.*	*Supines.*
posse	potens (used as adj. = powerful)	—
velle	volens	—
nolle	nolens	—
malle	—	—
ferre	ferens	latum, latu
fieri	—	—
ire	iens (*genitive* euntis)	itum, itu

Perfect Participle Passive.

Fio and *Fero* have perf. ptc. pass. *factus* and *latus*. *Factus* is used with *sum*, etc., to form the perfect tenses of *Fio*.

Feror (passive of fero) has pres. indic.: 2. ferris. 3. fertur.

Queo and *Nequeo*: Conjugated like *Eo*.

Edo (I eat) often changes some of its forms:

Ind. Pres. *2nd Pers. Sing.*	*Ind. Pres.* *3rd Pers. Sing.*
edis or es	edit or est

Infin.
edere or esse

Deponent Verbs. These are chiefly passive in form, but active in meaning—*e.g.*, *venor, venari* = to hunt; *utor, uti* = to use. They are found in each of the four conjugations. They are conjugated like the passive voice of a verb of the same conjugation: thus, *Venor* (like *amor*), *venari, venatus sum*. In the infinitive, however, they combine active and passive forms—*e.g.*, *Utor*:

Pres. infin.	uti, *to use*
Perf. infin.	usus esse
Fut. infin.	usurus esse
Supines.	usum, usu
Pres. ptc.	utens, *using*
Perf. ptc.	usus, *having used.*
Fut. ptc.	usurus
Gerunds.	utendum, -i, -o
Gerundive.	utendus

The fact of their having a perfect participle with an active meaning makes them very useful for translating the English "having used," "having hunted," etc. Thus, for "having spoken thus, the queen died," if we use the deponent *loquor, loqui, locutus* for "to speak," we can say *Ita locuta, regina mortua est.*" But if we used "*dico*" for "to speak," we could not use "*dictus*," which means "having been spoken." We should then have to say either (1) *his dictis* (these things having been spoken, abl. abs.) regina mortua est; or (2) *quum ita dixisset*, regina mortua est.

Semi-deponent Verbs. A few verbs have an active present, and a perfect of passive form; these are called "semi-, or half-deponents":

Audeo, *I dare*	*Perf.*	ausus sum, *I dared*
Fido, *I trust*	,,	fisus sum, *I trusted*
Gaudeo, *I rejoice*	,,	gavisus sum, *I rejoiced*
Soleo, *I am wont*	,,	solitus sum, *I was wont*

Section II. SYNTAX.

The Dative Case. 1. The dative is often used after the gerundive ptc. in —*dus* (and sometimes after other passive participles) where we should expect the ablative of the agent with the prep. *ab*—*e.g.*, *Hoc mihi faciendum est* = this is to be done (must be done) by me.

2. Predicative dative: that which a thing or person serves as, or occasions; much used with *sum, do, duco*, and (especially with military terms, *auxilio, praesidio, subsidio*) with verbs of motion—*e.g.*:

Quinque cohortes castris *praesidio* reliquit. He left five cohorts as a guard to the camp.

Quae res *saluti nobis fuit.*

Which thing was for a safety to us—*i.e.*, saved us.

Ipse sibi *odio* erit.

He will be an object of hatred to himself; *lit.*, he will be for a hatred.

Impedimento esse = to be a hindrance.

Detrimento esse = to be hurtful, etc.

3. The dative is sometimes used where we should use a possessive pronoun or the genitive, to give greater emphasis to the person mentioned: *Tum Pompeio ad pedes se projecerunt* = then they threw themselves at Pompey's feet.

4. The dative is used after several verbs: With *sum* it denotes possession—sunt nobis mitia poma = we have mellow apples. All the compounds of *sum* (except *possum*) take a dative.

Verbs signifying to Aid, Favour, Obey, Please, Profit, Injure, Oppose, Displease, Command, Persuade, Trust, Spare, Envy, Be angry, etc., take the dative, because they are really intransitive—*e.g.*, *Parce pio generi* = spare a pious race, *lit.*, "be sparing to."

[Although *Impero* (I command) takes a dative, *Jubeo* (I order) takes the acc.]

These verbs that take a dative cannot be used personally in the passive, but only impersonally—*e.g.*, *mihi persuasum est* = I have been persuaded, *lit.*, it has been persuaded to me.

A few impersonal verbs take a dative: *libet* (it pleases), *licet* (it is lawful), *accidit* (it happens), etc.—*e.g.* *libet mihi* = I am pleased; *lit.*, it is pleasing to me.

The Genitive Case. This denotes:

1. Possession: this is the simplest and most natural use of the genitive—*Cæsaris uxor* = Cæsar's wife.

The gen. sing. of a substantive is often used as a predicate with a copulative verb, to denote such English ideas as Nature, Token, Function, Duty, Part, Mark, etc.—*e.g.*, *Sapientis est tempori cedere* = it is (the mark) of a wise man to yield to circumstances. *Cujusvis* (gen. of *quivis*) *hominis est errare* = any man may err, it is (of the nature) of any man to err.

2. The relation of whole to part: Partitive Genitive—*e.g.*, *multi vestrum* = many of you. *Fortissimus Græcorum* = the bravest of the Greeks. *Duo horum* = two of these. Often used after the neut. sing. of adjectives and pronouns expressing quantity or degree, and with *nihil* (nothing), *satis* (enough), *parum* (too little)—*e.g.*, *parum prudentiae* = too little prudence. *Aliquid pulchri* (something beautiful); *quid novi*? (what news?).

Also used after some adverbs, *quo, eo, tum, ubi*, etc.—*e.g.*, *ubi gentium* = where in the world? *lit.*, where of nations?; *eo miserarium* = to such a pitch of misery; and even *ad id temporis*, to that point of time.

Note. (*a*) The whole of the city = *tota urbs* (not *totum urbis*); all of us = *nos omnes*—*i.e.*, we all. For in these instances we are not dealing with a part.

(*b*) It is equally good Latin to say "*viginti e suis servis misit*" as to say "*viginti servorum misit.*"

3. Quality or Definition. This is very like the ablative of quality, and the substantive

in the genitive is *always* accompanied by an adjective: *homo infimi generis* = a man of the lowest race; *vir summae fortitudinis* = a man of the highest courage; *puer sedecim annorum*, = a boy of sixteen years.

4. Price. Used especially with verbs of Valuing and Esteeming; confined to *pluris*, *minoris*, *tanti*, *quanti* (and their compounds), *magni*, *maximi*, *parvi*, *minimi* (probably through confusion with the old locative, which was the case used in expressions of value)—*e.g.*, *Parvi sunt foris arma, nisi est consilium domi* = of little value are arms abroad, unless there is a policy at home. [An old form *nihili* is used in this connection.]

5. The genitive is used after verbs and adjectives signifying power and impotence, innocence, condemnation, acquittal, memory and forgetfulness, and compassion—*e.g.*, *Parricidii eum incusat* = he taxes him with parricide. *Alii reminiscentes veteris famae, aetatis miserabantur* = others remembering their former renown, pitied their age. *Capitis* (or *Capite*) *damnatus est* = he was condemned to death.

[For the genitive of the object exciting mental emotion after certain Impersonal Verbs, see next lesson.]

Subjective Genitive and Objective Genitive. Such a phrase as "the love of God," is capable of two meanings. (1) God's love for us, in which case "of God" is subjective genitive; (2) Our love for God, when "God" is objective genitive. In other words, if the genitive represents the subject of a verb it is subjective; if it represents the object, it is objective. Both of these genitives may be combined in a single phrase: *Helvetiorum injuriae populi Romani* = the wrongs done by the Helvetii (subjective) to the Roman people (objective).

SENTENCES TO BE TURNED INTO LATIN.

[There are no actual words for Yes and No in Latin. An affirmative answer is expressed by *etiam*, *ita*, *factum*, *vero*, *verum*, *sane*, *ita vero*, *ita est*, *sane quidem*, etc., or by the proper pronoun, as *ego vero*; or by the verb repeated in the proper person—*e.g.*, *sentio*. A negative answer is expressed by *non minime*, *minime vero*; or with the pronoun, *minime ego quidem*; or with the verb, *non sentio*. When the contrary is asserted by way of reply, we have *immo*, *immo vero*, "No, on the other hand," "Nay rather."]

1. Do you think (begin the question with Num) God to be like me (genitive, after *similis*), or you? Certainly you do not think so. What then? Am I to call the sun or the moon or the sky God? No, assuredly not.

2. Why do you not enjoy what you have bought (say "the bought things," perf. ptc. pass. of *emo*)? Because I have bought them very dear.

3. I was persuaded to remain ten days at Cicero's house.

4. What is harder than a rock? What is softer than a wave?

5. He had come to such a pitch of boldness that (*ut*) he was unwilling to obey the general.

6. Always in a State those who have no wealth (say, those to whom there are no resources) envy the good (citizens).

7. In (*apud*) Vergil we read about the taking of Troy.

KEY TO ABOVE SENTENCES.

1. Num tu mei similem putas esse aut tui deum? Profecto non putas. Quid ergo? Solem dicam aut lunam aut cœlum deum? Minime vero.

2. Cur non emptis (*abl. after* fruor), frueris? Quod (or quia), maximi (or maximo), emi.

3. Mihi persuasum est ut decem dies apud Ciceronem manerem.

4. Quid est durius saxo, quid mollius unda?

5. Eo audaciæ venerat ut imperatori parere nollet.

6. Semper in civitate, quibus opes nullæ sunt, bonis invident.

7. Apud Vergilium de capta Troja legimus.

SECTION III. TRANSLATION.

Put into English:

Si linguis hominum loquar et angelorum, caritatem autem non habeam, factus sum aes resonans aut cymbalum tinniens. Et si habeam prophetiam et noverim mysteria omnia, omnemque cognitionem, et si habeam totam fidem, adeo ut montes transferam, caritatem autem non habeam, nihil sum. Et si insumam *alendis egenis*(a) omnia quæ mihi suppetunt, et si tradam corpus meum ut comburar, caritatem autem non habeam, hoc nihil mihi *prodest*(b). Caritas iram cohibet, benigna est caritas, non invidet caritas, non agit perperam, non inflatur: non agit indecore, non quærit quæ sua sunt, non exacerbatur, non cogitat malum. Non gaudet injustitia, gratulatur autem veritati; omnia tegit, omnia credit, omnia sperat, omnia sustinet: caritas nunquam excidit: sed et prophetiæ evanescent, et linguæ cessabunt, et cognitio evanescet. Ex parte enim cognoscimus, et ex parte prophetamus. Postquam autem advenerit quod perfectum est, tunc quod est aliquatenus, *ut*(c) inutile, tolletur. Quum essem infans, ut infans loquebar, ut infans sapiebam, ut infans ratiocinabar: postquam autem factus sum vir, ut inutilia *sustuli*(d) quæ infantis erant. Cernimus enim nunc per speculum et per ænigma, tunc autem coram cernemus: nunc novi aliquatenus, tunc vero amplius cognoscam, prout amplius edoctus fuero. Nunc vero manet fides, spes, caritas, tria hæc: maxima autem harum caritas.

NOTES. (*a*) dative of gerundive = for feeding the needy.

(*b*) from *prosum*, *prodesse*, *profui*.

(*c*) *Ut* with indic., or used without a verb, means "as."

(*d*) perfect of *tollo* (borrowed from *suffero*).

[For English of the above, see 1 Cor. xiii.]

Continued

 Continued from page 920

NOUNS AND ADJECTIVES

The Feminine

1. Certain nouns have masculine and feminine forms consisting of wholly different words, as in English. The chief of these are:

Masculine	*Feminine*
bélier, ram	*brebis*, ewe
bœuf, ox; *taureau*, bull	*vache*, cow
bouc, he-goat	*chèvre*, she-goat
cerf, stag	*biche*, hind
cheval, horse	*jument*, mare
cochon, pig	*truie*, sow
compère, gossip	*commère* gossip
coq, cock	*poule*, hen
garçon, boy	*fille*, girl
gendre, son-in-law	*bru*, daughter-in-law
homme, man	*femme*, woman
jars, gander	*oie*, goose
lièvre, hare	*hase*, doe-hare
mâle, male	*femelle*, female
mari, husband	*femme*, wife
monsieur, gentleman	*dame*, lady
neveu, nephew	*nièce*, niece
oncle, uncle	*tante*, aunt
papa, papa	*maman*, mamma
parrain, godfather	*marraine*, godmother
père, father	*mère*, mother
roi, king	*reine*, queen

2. Certain feminine forms retain the masculine stem, but are irregular in their termination:

Masculine	*Feminine*
ambassadeur, ambassador	*ambassadrice*, ambassadress
canard, drake	*cane*, duck
compagnon, companion	*compagne*, companion
devin, soothsayer	*devineresse*, soothsayer
dieu, god	*déesse*, goddess
dindon, turkey	*dinde*, turkey-hen
duc, duke	*duchesse*, duchess
empereur, emperor	*impératrice*, empress
gouverneur, governor	*gouvernante*, governess
héros, hero	*héroïne*, heroine
loup, wolf	*louve*, she-wolf
mulet, mule	*mule*, mule
perroquet, parrot	*perruche*, parrot
poulain, foal	*pouliche*, filly
serviteur, servant	*servante*, servant

3. The names of many animals have only one form. In that case, when there is any necessity for indicating the difference of sex, it is done by adding the word *mâle* or *femelle*.

Formation of the Feminine

Such nouns as have feminine forms follow the same rules as adjectives for the formation of the feminine. These rules are as follow:

1. To form the feminine of nouns and adjectives, add a mute *e* to the masculine: *grand*, *grande*, large; *petit*, *petite*, small; *marquis*, *marquise*, marquess; *ami*, *amie*, friend.

2. If the masculine ends in mute *e*, no change takes place: *jeune* (m. and f.), young; *aimable* (m. and f.), amiable.

Exceptions: The following nouns, ending in mute *e*, form their feminine by changing *e* into *esse*:

âne	ass	*ânesse*
chanoine	canon	*chanoinesse*
comte	count	*comtesse*
druide	druid	*druidesse*
hôte	host	*hôtesse*
maître	master	*maîtresse*
mulâtre	mulatto	*mulâtresse*
nègre	negro	*négresse*
prêtre	priest	*prêtresse*
prince	prince	*princesse*
prophète	prophet	*prophétesse*
tigre	tiger	*tigresse*
traître	traitor	*traîtresse*

When *mulâtre* and *nègre* are used as adjectives they have the same form for both genders.

3. Nouns and adjectives ending in *el*, *eil*, *en*, *ien*, *on*, *et*, in the masculine, form their feminine by doubling the final consonant and adding mute *e*: *mortel*, *mortelle*, mortal; *pareil*, *pareille*, similar; *européen*, *européenne*, European; *musicien*, *musicienne*, musician; *mignon*, *mignonne*, dainty; *muet*, *muette*, mute.

Exceptions: The following adjectives in *et*, instead of doubling the *t* before adding mute *e*, take a grave accent on the *e* that precedes it:

complet	complete	*complète*
incomplet	incomplete	*incomplète*
concret	concrete	*concrète*
discret	discreet	*discrète*
indiscret	indiscreet	*indiscrète*
inquiet	anxious	*inquiète*
replet	corpulent	*replète*
secret	secret	*secrète*

4. The following adjectives also form their feminine by doubling the final consonant and adding mute *e*:

bas	low	*basse*
épais	thick	*épaisse*
exprès	express	*expresse*
gentil	pretty	*gentille*
gras	fat	*grasse*
gros	big	*grosse*
las	tired	*lasse*
nul	null	*nulle*
pâlot	palish	*pâlotte*
paysan	peasant	*paysanne*
vieillot	oldish	*vieillotte*

5. The five adjectives, *beau*, *nouveau*, *fou*, *mou*, and *vieux*, which are used only before nouns beginning with a consonant or aspirated *h*, have a second masculine form, *bel*, *nouvel*, *fol*, *mol*, and *vieil*, which is used before a vowel or silent *h*. The second masculine form of these adjectives is *not* required in the plural, because there the final *x* or *s* prevents any harshness of sound before a vowel. Thus, the plural form

of *beau* and of *bel* is *beaux*. The feminine is got from this second form by doubling the final *l* and adding a mute *e*:

beau, bel	beautiful	*belle*
nouveau, nouvel	new	*nouvelle*
fou, fol	mad	*folle*
mou, mol	soft	*molle*
vieux, vieil	old	*vieille*

6. Nouns and adjectives ending in *er* form their feminine by putting a grave accent on the *e* preceding the *r*, and adding mute *e*: *léger, légère*, light; *premier, première*, first; *berger, bergère*, shepherd; *laitier, laitière*, milkman.

7. The feminine of adjectives ending in *gu* is formed by adding a mute *e* with a diæresis (*ë*): *aigu, aiguë*, sharp; *ambigu, ambiguë*, ambiguous.

8. The feminine of adjectives ending in *f* changes *f* into *ve*: *vif, vive*, lively; *bref, brève*, short; *neuf, neuve*, new.

9. The feminine of adjectives ending in *x* is formed by changing *x* into *se*: *heureux, heureuse*, happy; *jaloux, jalouse*, jealous.

Exceptions:

doux	*douce*	sweet
faux	*fausse*	false
préfix	*préfixe*	prefixed
roux	*rousse*	red-haired
vieux	*vielle*	old

10. Of the few adjectives ending in *c* the following three form their feminine by changing *c* into *che*:

blanc	*blanche*	white
franc	*franche*	frank
sec	*sèche*	dry

The others change *c* into *que*:

caduc	*caduque*	decrepit
public	*publique*	public
turc	*turque*	Turkish

Grec, Greek, retains the *c*, *grecque*. When *franc* means Frankish, its feminine is *franque*.

11. Nouns and adjectives ending in *eur* form their feminine in four different ways:

(*a*) Nouns and adjectives in *eur* derived directly from the present participle of verbs by changing *ant* into *eur*, form their feminine by changing *eur* into *euse*: *trompeur, trompeuse*, deceitful; *boudeux, boudeuse*, sulky; *danseur, danseuse*, dancer; *pêcheur, pêcheuse*, fisher.

(*b*) Nouns and adjectives ending in *eur* preceded by *t* (*teur*), in which the *t* belongs to the ending and not to the stem of the word, form their feminine by changing *teur* into *trice*. Many of them have corresponding English forms in tor: *acteur, actrice*, actor; *conducteur, conductrice*, conductor; *créateur, créatrice*, creator; *exécuteur, exécutrice*, executor. This rule does not apply to such words as the following, in which the *t* belongs to the stem: *acheteur, acheteuse*, buyer; *menteur, menteuse*, liar; *flatteur, flatteuse*, flatterer; *porteur, porteuse*, bearer.

(*c*) Nouns and adjectives ending in *érieur* (English *erior*), together with the three words *meilleur*, better; *majeur*, major, and *mineur*, minor, form their feminine regularly by the addition of mute *e*: *supérieur, supérieure*, superior; *inférieur, inférieure*, inferior.

(*d*) Some words in *eur*, that may be used both as adjectives and as nouns, form their feminine by changing *eur* into *eresse*. They are:

enchanteur	*enchanteresse*	enchanting
pécheur	*pécheresse*	sinner
vengeur	*vengeresse*	avenger

In legal phraseology *défendeur* and *demandeur*, defendant and plaintiff, have the feminine forms *défenderesse* and *demanderesse*.

The ordinary feminine of *chanteur* is *chanteuse*, but when applied to a professional singer it is *cantatrice*. *Chasseur*, hunter, if ever used in the feminine, has both *chasseuse* and *chasseresse*. The latter form is poetical, and occurs almost exclusively in connection with Diana and her nymphs. *Imposteur* has no feminine form as a noun, and is never used in the feminine as an adjective.

(*e*) The following forms do not come under any special rule:

long	*longue*	long
oblong	*oblongue*	oblong
bénin	*bénigne*	benign
malin	*maligne*	malicious (sly)
coi	*coite*	still (snug)
favori	*favorite*	favourite
frais	*fraîche*	fresh

(*f*) *Tiers*, an old form of the ordinal numeral, third (now *troisième*), is still used in a few expressions, and has *tierce* as its feminine, as *une tierce personne*, a third party.

Hébreue, as the feminine of *hébreu*, Jewish, is seldom used; it is only applicable to persons, and is practically superseded by *juive*, Jewish. In any other case, the feminine form *hébraïque* is used, thus; *la langue hébraïque*, the Hebrew language.

When the feminine form of a noun or of an adjective requires a grave accent it is for the purpose of preventing two mute syllables—that is, two syllables ending with a mute *e*—from coming together, thus: *sec, sè-che*; *bref, brè-ve*; *berger, bergè-re*; *secret, secrè-te*.

In *exprès* the grave accent of the masculine form disappears in the feminine, because the open sound which it gives the *e* is obtained by the addition of *se*, and it consequently becomes superfluous.

The diæresis on the mute *e* of such feminine forms as *aiguë* indicates that the sound of the *u* is to be retained. Without it the *g* alone would be heard as in the English word "egg."

The addition of mute *e* to a noun or adjective ending with a consonant causes the final letter, which is frequently silent in the masculine, to be distinctly heard, thus *savan(t)*, *savant(e)*, learned. In the case of a vowel ending, the mute *e* slightly lengthens the vowel sound, thus: *joli, jolie*, pretty; *ami, amie*, friend.

The plural of the feminine forms is formed like that of the masculine by adding *s*: *Les poires sont bonnes*, the pears are good.

Adjectives agree in gender and number with the nouns which they qualify, thus: *l'arbre est haut, les arbres sont hauts; la belle fleur, les belles fleurs.*

To be continued

SPANISH Continued from page 780

By José Plá Cárceles, B.A.

Qualifying Adjectives. Adjectives generally follow the substantives to which they refer, and agree with them in gender and number. Adjectives ending in *o* become feminine by changing this final letter into *a.*—*el plato blanco*, the white plate; *la taza blanca*, the white cup. Those ending in *an*, *on*, or signifying nationality and ending in a consonant, form their feminine by adding an *a*. *un muchacho holgazán*, a lazy boy; *una muchacha holgazana*, a lazy girl. All other adjectives have only one termination for both genders.

The Plural of Adjectives. The plural of adjectives is formed in the same manner as the plural of nouns, by adding *s* or *es* according to their termination. An adjective qualifying two or more words of different gender takes the masculine plural form.—*el caballero y la señora son españoles*, the gentleman and the lady are Spanish.

The adjectives *alguno*, some; *bueno*, good; *malo*, bad; *ninguno*, not any, none; *cualquiera*, any, are contracted to *algún*, *buen*, *mal*, *ningún*, and *cualquier* before a masculine singular noun—*un buen hombre*, a good man; *ningún cuadro*, no picture. *Cualquiera* is also contracted in front of a feminine singular noun—*cualquier calle*, any street. *Grande*, meaning great, is contracted to *gran*, and placed before the noun it qualifies.—*un gran pintor*, a great painter.

Exercise VII on *Ser* and *Estar*

1. Are you business men from Madrid? 2. No; I am (a) lawyer and my friends are physicians. 3. Is the steamer in the bay? 4. No, sir; not yet. 5. Is that gentleman your father? 6. No; he is my uncle. 7. Are we near his factory? 8. No; it is very far from here. 9. Where are my trunks? 10. They are on the platform, number five. 11. Are you sea-sick? 12. No, thanks; I am very well. 13. Is the door of the dining-room in the garden? 14. No; it is now in the station to the right of the booking-office. 15. Are you (plural) foreigners? 16. Yes, sir; we are Spaniards. 17. Where are we (fem.) now? 18. You are in the custom-house. 19. Is the clerk in the office? 20. No, madam; he is on board the steamer from Valparaiso.

Exercise VIII

The month	*El mes*	The anchor	*El ancla*
The salary	*El salario*	The ship	*El buque*
The bird	*El ave*	The wing	*El ala*
The neighbour	*El vecino*	Pronunciation	*Pronunciación*
Hunger	*El hambre*	The eye	*El ojo*
The flour	*La harina*	The soul	*El alma*
A beggar	*Un mendigo*	A jewel	*Una joya*
The bread	*El pan*	The tree	*El árbol*
Short	*Corto*	Small	*Pequeño*
German	*Alemán*	Beautiful	*Hermoso*
Narrow	*Estrecho*	Immortal	*Inmortal*
Long	*Largo*	The cigar	*El cigarro*
Polite	*Cortés*	Italian	*Italian*
Jolly	*Alegre*	Difficult	*Difícil*
The weather	*El tiempo*	Hard	*Duro*
Too	*Demasiado*	White	*Blanco*

I do not understand—*No comprendo*

Translate: 1. A clerk's salary. 2. The horses' eyes. 3. The beggar's bread is hard. 4. My neighbour's tree is too high. 5. Man's soul is immortal. 6. The American flour is very good. 7. The streets are long and narrow. 8. The bird's wings are short and white. 9. The German ship's anchor is too small. 10. Her sister's jewels are beautiful. 11. The French bread is good. 12. My father and mother are well. 13. The house and the garden are large. 14. Your Italian friend (fem.) is very polite and jolly. 15. (The) English pronunciation is difficult. 16. Any white paper. 17. Bad weather.

Degrees of Comparison. The comparative is formed by placing *más* (more) and *menos* (less) in front of the adjective—*más blanco*, whiter; *menos duro*, less hard. The comparative forms of the adjectives *grande*, *pequeño*, *bueno*, *malo* are *mayor*, *menor*, *mejor*, *peor*. These words have no gender, and they form the plural in the usual manner.

In comparisons of equal degree, "so-as" and "so much-as" are translated by *tan-como* and *tanto-como* respectively. *Tanto* being an adjective, it agrees in gender and number with the following noun. "Than" is translated by *que*—*el comedor es mayor que la sala*, the dining-room is larger than the drawing-room; *no es tan jóven como Vd.* he is not so young as you. Whenever "than" is followed in the English sentence by a verb, it must be rendered in Spanish by *de lo que*.—*es más rico de lo que dice*, he is richer than he says.

Demonstrative Adjectives and Pronouns. Demonstrative adjectives and pronouns agree in gender and number with the nouns to which they relate. They are as follow:

	Singular			*Plural*	
	M.	F.	N.	M.	F.
This	*este*	*esta*	*esto*	*estos*	*estas*
That	*ese*	*esa*	*eso*	*esos*	*esas*
That	*aquel*	*aquella*	*aquello*	*aquellos*	*aquellas*

The neuter forms have no plural. *Este* denotes proximity; *ese*, moderate distance, and *aquel*, remoteness (that yonder).

Exercise IX

1. This book is larger than that. 2. Is that the station? 3. That stick is my brother's. 4. These newspapers are Spanish. 5. I do not understand that. 6. It is not that. 7. These cigars are better than those. 8. My brother is not so tall as you. 9. This lesson is not so difficult. 10. Those houses are nearer than the factory.

Translation of "to have." The verb "to have" may be translated either by *tener* or

haber. *Tener* is used as an active verb denoting possession.—*yo tengo un sombrero,* I have a hat.

Haber is simply an auxiliary verb, and it can therefore never be used except before a past participle.—*yo he comprado un bastón,* I have bought a stick.

PRESENT INDICATIVE OF *Tener*

Singular	*Plural*
yo tengo, I have	*nosotros tenemos,* we have
tu tienes, thou hast	*vosotros teneis,* you have
el, ella, Vd tiene, he, she, it has, you have	*ellos, ellas, Vds tienen,* they, you have

PRESENT INDICATIVE OF *Haber*

Singular	*Plural*
yo he, I have	*nosotros hemos,* we have
tu has, thou hast	*vosotros habeis,* you have
el, ella, Vd ha, he, she has, you have	*ellos, ellas, Vds han,* they, you have

EXERCISE X

Looking-glass	*Espejo*	Bag	*Maleta*
Piano	*Piano*	Boots	*Botas*
Dress	*Vestido*	Pair	*Par*
Sugar	*Azúcar*	Agent	*Agente*
Situation	*Destino*	Room	*Cuarto*
Telephone	*Teléfono*	Cashier	*Cajero*
Matches	*Fósforos*	Seen	*Visto*
Address	*Dirección*	Left	*Dejado*
Written	*Escrito*	Come	*Venido*
Bought	*Comprado*	Gone	*Ido*
Sold	*Vendido*	Lost	*Perdido*
Received	*Recibido*	To write	*Escribir*
Found	*Encontrado*	To sign	*Firmar*
To have to	*Tener que*	To speak	*Hablar*
Who	*Quién*	Why	*Por qué*
As soon as possible	*Lo antes posible*	That, which	*Que*
		Enough	*Bastante*
To be hungry, thirsty, cold, hot, sleepy, afraid, ashamed		*Tener hambre, sed, frío calor, sueño, miedo, verguenza*	

TRANSLATE: 1. I have a good looking-glass in my room. 2. We have left our bags in the train. 3. Are you thirsty ? 4. Why have you not gone to London ? 5. Have they found her blue dress ? 6. Has she enough sugar ? 7. We have no telephone in the office. 8. I have lost your address. 9. He has a good situation in Mexico 10. Have they come ? 11. Have I to sign that paper ? 12. You have to write as soon as possible.

KEY TO EXERCISE III

1. el. 2. el. 3. el. 4. la. 5. la. 6. el. 7. el. 8. la. 9. la. 10. el. 11. la. 12. el. 13. el. 14. la. 15. el. 16. el. 17. la. 18. la.

1. plantas. 2. tinteros. 3. trenes. 4. cofres. 5. reyes. 6. claveles. 7. perros. 8. jabalíes. 9. tierras. 10. españoles. 11. mares. 12. peces. 13. muelles. 14. pueblos. 15. malecones. 16. playas. 17. perdices. 18. relojes.

KEY TO EXERCISE IV

1. My father. 2. Your book. 3. His pencil. 4. Thy chair. 5. Our paper. 6. His, her, your letter. 7. My flowers. 8. Their lessons. 9. Your (pl.) pipes. 10. Our hats. 11. Her gum. 12. My envelope. 13. Your house. 14. Thy dressmaker. 15. My horses. 16. His stick. 17. Our King. 18. Her dog.

1. Su despacho (de Vd). 2. Mis giros. 3. Nuestra casa. 4. Su lacre (de él). 5. Mi padre. 6. Sus perros (de ella). 7. Sus tiendas (de ellos). 8. Sus cheques (de Vd). 9. Nuestra reina. 10. Su comedor. 11. Su bastón (de él). 12. Sus cartas (de ellos). 13. Sus copias. 14. Su factura (de Vds). 15. Su cocina (de ella). 16. Nuestras lecciones. 17. Tu hermana. 18. Tus amigos.

KEY TO EXERCISE V

1. He is (an) Englishman. 2. Are you Spaniards ? 3. I am not (a) lawyer. 4. We are foreigners. 5. Is that my train ? 6. We are clerks. 7. Who is the manager ? 8. You (pl.) are not the owners of the factory. 9. I am a passenger in (of) that train. 10. The frontage of the custom-house is blue. 11. His bedroom is large 12. Thou art not tall. 13. Are you (a) business man ? 14. They are foreigners.

1. ¿ Es Vd el jefe de la oficina ? 2. No, señor, no soy el jefe ; soy un empleado. 3. ¿ Quién es el abogado de su amigo ? 4. Ellos son nuestros obreros. 5. La fábrica no es muy grande. 6. Todos sus empleados son ingleses. 7. Vds no son españoles. 8. ¿ Es él el dueño del (de el) negocio ? 9. Nosotros no somos extranjeros. 10. Su billete (de Vd) es azul. 11. ¿ Es Vd su tío (de él) ? 12. ¿ Es ese edificio la aduana ? 13. Ella es modista. 14. ¿ Quién es Vd ? 15. Yo soy uno de sus empleados (de él).

KEY TO EXERCISE VI

1. How are you ? 2. I am not very well ; I am very tired. 3. Where is the manager of the station (station master) ? 4. He is not here ; he is in the booking-office. 5. Are we in London already ? 6. No, madam ; we are now in Dover. 7. Are you tired ? 8. No, sir ; and you ? 9. Neither am I ; many thanks. 10. Where is she ? 11. She is in New York, but her father is in Buenos Aires. 12. Are all the trunks on board ? 13. Who is in the garden with the workmen ? 14. My friend is very far from here ; he is engaged in the mines of Colombia. 15. Is he ill ? 16. I do not think so.

1. ¿ Estamos ya en la fábrica ? 2. No, señor ; estamos en la estación. 3. ¿ Es este el andén para Madrid ? 4. No, señor ; el andén para Madrid está á la derecha. 5. ¿ Quién está encargado de los boules ? 6. Mi tio ; pero no está aquí todavía. 7. ¿ Como está (él) ? 8. Está muy bien, gracias. 9. ¿ Está Londres cerca de la costa ? 10. No, está en el Támesis. 11. ¿ Dónde está el vapor para Montevideo ? 12. Â la izquierda de la estación, señora. 13. ¿ Está Vd enfermo ? 14. Estoy un poco mareado. 15. ¿ Estamos cerca de la oficina ? 16. No, Vds estan muy lejos (de ella).

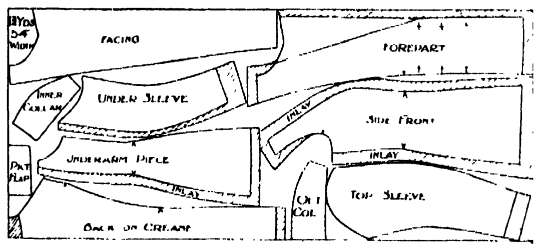
(*To be continued*)

Cutting and Making-up a Russian Coat and a Loose Wrap. Shrinking and Stretching.

COAT CUTTING AND MAKING

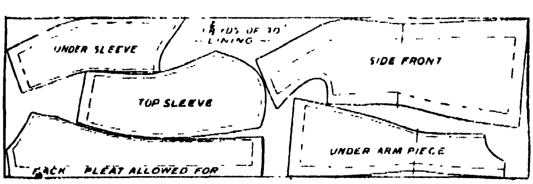
Cutting the Material. Short coats not exceeding 32 in. in length can usually be cut from 1¾ to 2 yds. of 54 or 56 in. cloth, without unduly cramping parts or dispensing with good inlays and turn-ups. Open out the cloth and examine it for damages. These are usually marked by the aid of strings secured to selvedge by the woollen merchants, and it is rare indeed that such passes their critical eye. However, fold over the length with the crease on the nearest, and selvedge on farthest, side [23].

Before placing the parts down, see if the material has a way of the wool. This can soon be found by passing the hand to and fro lengthwise when the pile, if present, can be felt. Should this be evident in ever so slight form, arrange the cloth so that the pile runs from left to right, and see that all parts of the pattern are placed down with the bottom edge to the right. Lay the front edge to the selvedge, follow with the side-front and top sleeve. Place the collar pattern with the centre of back on the fold. Place the back in left corner to the fold, and follow with the other pieces in the order shown.



23. CUTTING OUT THE MATERIAL

Before marking any part, notice where the inlays and turn-ups are added, and manipulate the parts accordingly. Inlays, etc., are marked by shaded lines. The inner collar cut from the bias of cloth is the same size as the pattern, but the outer collar should be rather larger, both in length and width, than this. Mark the position of holes and buttons, also the waist-line and sleeve pitches, plainly.



24. CUTTING OUT THE LINING

The facing is merely a repetition of the front section, but may be reduced slightly in width, or even pieced, if length does not permit of this part being cut whole. It is not always customary to cut every part out, especially when cutting for others to make up, as some tailors prefer to cut their own fittings, such as collars, flaps, and facings.

The lining may be cut out by the aid of the paper pattern, while some lay the cut-out cloth upon the lining. Whichever plan is resorted to (the use of patterns provides more scope for economic placement) there must be no stint of either length or width. Diagram 24 shows, by aid of dash lines, the surplus needed for ease when felling. The side seam of back, sleeve-seams, and the front seam of side-piece should have ½ in. of surplus width; while other parts should be increased as shown, comprising a pleat down the back, and 2 inches on side-front section over the breast.

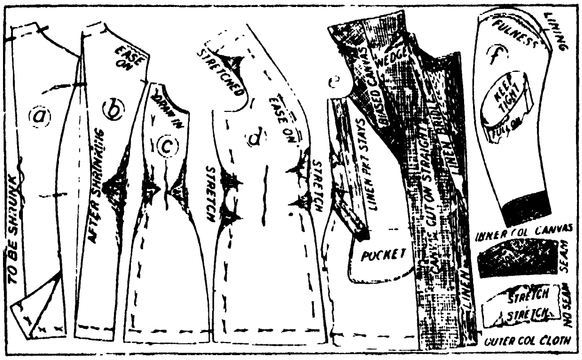
When linings are needed to be machined up before putting in, more careful treatment is needed, and they must be cut more in harmony with the pattern, with much less surplus than is here shown.

Hints on Making. As so much of the fitting qualities of our coat depends upon the making up, etc., we must pause before showing the cutting of other styles in order to emphasise a few essential points affecting this particular style of garment. In the first place, there are but few seams. Consequently, we must rely greatly upon the skill of the worker to infuse shape with the iron.

As a simple instance of the value of manipulation—i.e., shrinking and stretching—we might point to the outline of our back section as cut. One will readily estimate that if this part is made up without receiving treatment with the iron there will be surplus cloth in the back waist which will prove unsatisfactory. The part marked *a* in illustration 25 is the section in question as it leaves the cutting board, except that the marking stitches have been put in according to the cutter's instructions, conveyed by chalk marks. The top inlay, sleeve pitch, waist-line and bottom inlays have been marked with basting cotton, and the top layer has been lifted at the bottom corner, the stitches having been cut so that both layers are marked; *b* shows how the iron has been applied to the edges at the waist and worked downward, while by the left hand the operator has strained the cloth, producing the hollow in the centre of back, imitating the effect of a seam at that part.

Shrinking. The beginner may imagine that to shrink a certain portion one merely stretches the surrounding parts, and although this is correct to a degree, it is not wholly so,

for the practised hand really does gather up cloth by the action of the iron, and after well damping the surplus stuff removes it as far as the nature of that particular cloth will allow. This operation is applied at other parts in similar manner. The portion to be shrunk is folded, creasing the line marked by the cutter (see wavy mark on straight line, which is the trade sign for "shrink"), and the edges strained, always downward, and the surplus so produced on the crease, "boiled" away. It will be seen that if the operation is properly carried out, and the iron kept on the cloth till it is well set, or dried, the effect is quite as good from the fitting standpoint as a seam. The scye end of shoulder, both edges of the biased collar canvas (after having been padded to biased cloth), and the edge of the cloth for the outer collar need to be well stitched.



25. SHRINKING THE COAT INTO SHAPE

The main support of the fronts is formed by French canvas, of which 1¼ yd. is used for coat. As will be seen by the diagram, the front interlining will be cut from the selvedge of canvas, and the collar and shoulder parts being biased, they can be taken from between the larger sections. Snip the canvas at the gorge and put in a wedge, so that the snip opens about ¾ in. Also strain the shoulder end again.

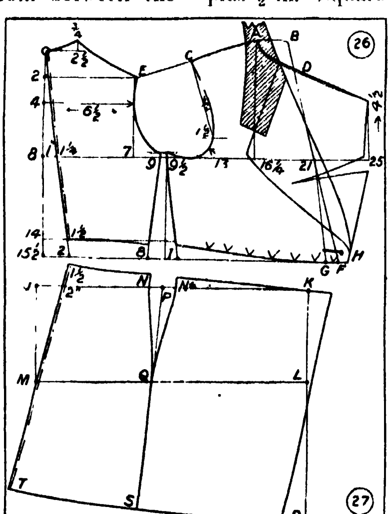
The pockets, if any, should be stayed with strips of linen from the scye and side seam, and the making of the flaps and tackings should all be strongly and neatly finished. See that the flaps curl inward before being pressed. When basting in the canvas, see that it has the same form as the covering, and do not spare the basting cotton, tacking always with a view to giving length through the hollows of shoulder and waist, and keeping it snug over the breast. Tailors use the knee, over which the garment is thrown; it is then more convenient to ease on or hold tightly, as the case may be. The edges need holding tightly by a strip of linen, and a bridle of linen is put on along the break again on the short side, so as to draw it slightly. Pad revers thickly, and in such a way that they curl back. The fulness caused by the action of linen being short needs the application of a sharp iron, in order that it can be worked over the prominence of bust.

When putting in the sleeves, start the top fulness at 1 in. from shoulder seam, and terminate it at 2 in. from front pitch. The under sleeve must be kept very tight when sewing the back scye, but at the base it is eased about ¾ in. [**25 f**].

Russian or Basque Coat. This is a standard type of garment which will always be popular, and while small details, such as the run and position of waist-seam, style of collar, length, etc., may alter each season, the basis of drafting basqued styles in general remains the same [**26**].

Choosing Size 4 again we will briefly explain the cutting. When measuring, take the length from nape to approximate position of waist-seam in addition to those stated. Sample set, 36, 24, 40, 14, 15½, 31, 6, 17. Scale 18.

Rule line O 15½ the waist length, and come up 1½ in. for position of seam—viz., 14 in. from nape. At waist go in 2 in., and rule back line to O. O to 2, 2 in.; to 4, 4 in. O to 8, one-third of scale, plus 2 in. Square lines out from each point. O to 2½, one-sixth, less ½ in. Raise ¾ in., as shown. On line 4 apply the back width, plus ½ in. Square up to meet this measure.


26-27. RUSSIAN BASQUE COAT

From 1 to 21, half chest, plus 2 in. Go back half scale less 1 in. to find point 13. Raise 1½ in.

Halve from 13 to 21, and go back ¾ in. Square up to A half scale.

Rule A to E, and make A to C ¼ in. less than back shoulder.

A to B one-sixth, less ½ in. Rule B through 21 to F. Go back from F to V 1 in. for the true centre line of figure.

G to H, 2 in. From 21 to 25 is 4 in., from which point square up to 4½ in. Shape the sleeve, taking out 1 in., and slope it towards the prominence of breast.

B to D, one-sixth, less 1 in.; shape front edge and gorge. From 1 to 9 one-fourth of chest measure, less 1 in., and from 2 to point 8 at waist measure one-fourth of the waist—viz., 6 in. At 8 go up 1¼.

From 9 to 9½ mark ½ in. always, from which point square down to waist and go in 1 in., as shown. At I go up 1¼, and curve bottom to point G at waist.

The Basque. J to K, half seat plus ½ in., and from J square down to M 7 in., and across to L

[27]. Go in 2 in. at J, and rule back through M. Rise $1\frac{1}{2}$ in. at top to agree with the height, seam is placed above the waist.

From 2 to N, one-fourth of waist, plus $\frac{1}{2}$ in.; or make $1\frac{1}{2}$ to N equal width of bottom and back section. Square down from N to find Q. N to P 1 in. N to N* 2 in. Rule P, Q, S for side seam. Let O to $1\frac{1}{2}$ in diagram 26, and from $1\frac{1}{2}$ to T equal 1 in. more than the length. Make K L $\frac{3}{4}$ in. longer than from 2 to T.

Go out 2 in. at K to agree with G H in Diagram 26. Slope the front away at R half the desired opening.

By making R 2 in. back from square line, the corners should be open 4 in. Cut $\frac{1}{4}$ in. off centre of back of both diagrams for whole back.

The cutting of this collar is the same as diagram 22, but the silk covering is arranged to overlap the drawing seam about $\frac{3}{4}$ in.

Wrap Coat. Owing to the fact that long winter coats and ulsters have to be worn over a variety of underwear, they must necessarily be cut a trifle larger about the shoulders and scye, and in order to bring this about without resorting to any drastic change in our method, we advocate adding 1 in. to the scale. Thus for a 36 chest use the 19 scale.

The style chosen is a cutaway wrap with laid-on collar and moderate breast overlap. The body defines the figure very slightly, and there is a cut from the shoulder to the breast to facilitate the fit at that part. Side seams are finished with either slits or pleats.

Many of these garments are made up unlined except for sleeve linings, and a "buggy" lining at back (see dot-and-dash lines, showing the termination of lining and position of cloth facing to which it is felled). Silk serge, Polonaise or Italian are suitable materials for this purpose.

The Drafting. Rule line O 50 to the desired length, and mark the depths as before stated [28]. Square lines out. Add $\frac{1}{2}$ in. across the back, and shape back shoulder. From $\frac{1}{2}$ to $20\frac{3}{4}$ measure half chest plus $2\frac{1}{2}$ in. Then go back to A half scale, less $\frac{1}{2}$ inch.

Square up and down from $20\frac{3}{4}$ for the centre line of front; to B half scale. Square back to C one-sixth, less $\frac{1}{2}$ in. B to H, one-sixth.

Rule C to D, and place E at about $2\frac{1}{2}$ in. from C. Raise $\frac{1}{2}$ in. at E. E to F, 2 in. F to G, complete the shoulder-seam length to $\frac{1}{4}$ in. more than back.

Raise $\frac{1}{2}$ in. at F. Shape scye. Halve from A to $20\frac{3}{4}$, and mark * at $2\frac{1}{2}$ in. down. Shape the sleeve as shown. Add $3\frac{1}{2}$ in. overlap at breast and waist, and draw line of fronts across centre line at 12 in. up from D; also round the edge at $5\frac{1}{2}$ in. from D.

A to 10 $2\frac{1}{2}$ in. Square down, and go forward $\frac{1}{2}$ in. for edge of cut, and take out $\frac{1}{2}$ in., terminating the seam at 4 in. down.

Square down from point $6\frac{3}{4}$, and shape back side seam by this guide line, hollowing it slightly above waist, and adding $1\frac{1}{4}$ at hip line. Make bottom of back from L to K 2 in. more than from $\frac{1}{2}$ to $6\frac{3}{4}$. Run the seam into the syce at $1\frac{1}{2}$ in. up from the scye level, and add $\frac{1}{4}$ beyond the line for run of scye.

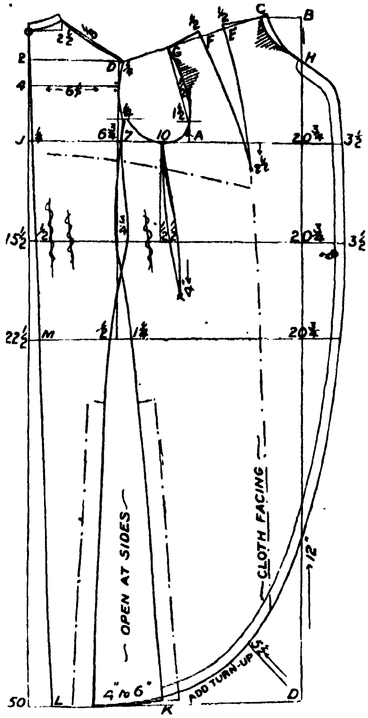
Take out $\frac{3}{4}$ in. suppression at the seam, and overlap the seat so as to produce $1\frac{1}{2}$ in. in excess of the measure for seams and ease; that is to say, for a 40 seat. The parts $20\frac{3}{4}$ to $\frac{1}{2}$ and from M to $1\frac{1}{4}$ added together should measure $21\frac{1}{2}$ in.

Let the bottom overlap from 4 to 6 in., and add $1\frac{1}{2}$ in. as dot-and-dash lines for pleat or slit opening. Add $\frac{1}{2}$ in. for collar stand at neck of both back and front.

When cutting from the cloth leave on good inlays at the side seam and front edge, and merely baste the breast. Cut for fitting in order that the quantity of suppression at that part can be varied.

The Collar. It will be seen that the stand of collar is "grown" on the neck of body part, therefore the collar will be void of this portion. Pin the vee F, E, $2\frac{1}{2}$ together, and lay the part in a closing position with the back shoulder seam—in other words, place the parts down as they will be when sewn. Let D overlap G one inch, while C is but touching the back neck.

Now trace the collar similar to the design, noting the position of the meeting ends of same.



28. A WRAP COAT

29. THREE TYPICAL STYLES

Martin, Siemens and Siemens-Martin Processes. Open-hearth Steel Manufacture. Steel Castings, Steel Rails.

OPEN-HEARTH STEEL

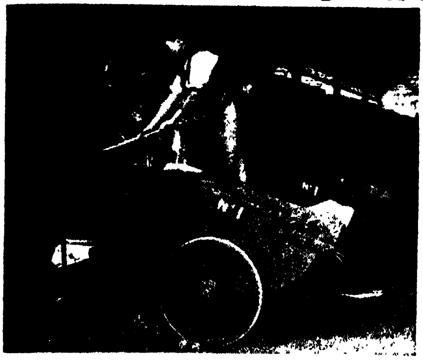
The manufacture of steel in the open-hearth regenerative furnace is becoming more and more popular, and very great strides have been made in recent years through the introduction of the tilting furnaces, as well as by the increasing size of the stationary furnaces. The invention of the open-hearth furnace and its accessories is due to Sir William Siemens, and the successful manufacture of good steel in it was first accomplished by Messrs. P. and E. Martin, who used steel scrap and pig iron, dissolving the scrap in the molten pig iron, thus diluting the impurities as well as partially removing them by oxidation. This was termed the *Martin process*. Siemens afterwards succeeded in desiliconising and decarburising pig iron, with or without scrap, by means of oxide of iron ore. At the present time both oxide of iron and scrap are used with the pig iron, forming the Siemens-Martin process. The original method was to work only with an acid lining, but now both acid and basic linings are used, as in the Bessemer process.

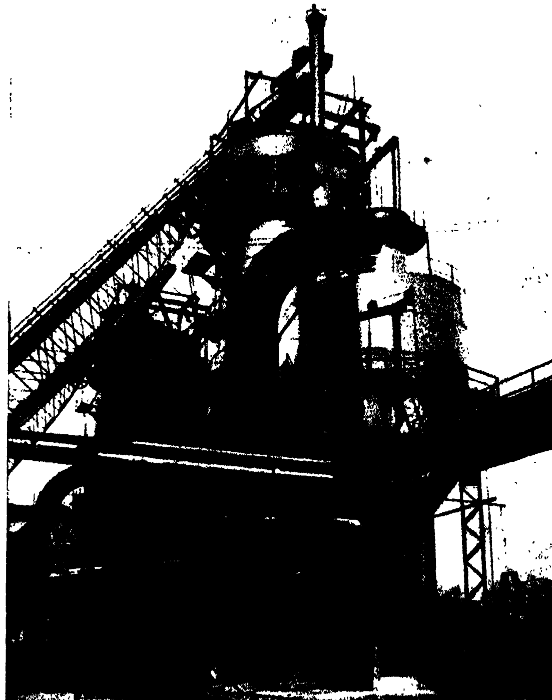
The Martin Process. The Martin process is conducted as follows. The first thing is to solidify the bottom, which has been carefully prepared with good silica sand, by melting a small charge of pig iron and adding siliceous material to form a fluid slag. When this is melted it is well rabbled about to wash the banks of the furnace and then tapped out as scrap. The next three or four heats are less than the full charges afterwards worked, and consist of pig iron and a little scrap, the latter being gradually increased till the furnace is in good working order. The materials may be charged cold, or the scrap may be first heated to redness in an auxiliary furnace. Grey hæmatite pig iron of good quality, preferably low in silicon and containing manganese, is desirable, but a proportion of good white or mottled iron may be added. The pig iron—from 15 per cent. to 20 per cent. of the charge—is first added and upon this is placed steel scrap.

When the charge is melted it may be kept in fusion, because the intensity of the oxidising action may be easily maintained. In order to hasten the operation the pig iron may be charged into the furnace in the liquid state, and speedily raised to a white heat. The malleable iron, previously made red-hot, is then added in lumps. With a neutral flame, No. 1 grey pig iron will dissolve nine times its weight of Bessemer scrap, while No. 3 will not dissolve more than four times its weight, and, when the flame is oxidising, considerably less. The oxide of iron, Fe_3O_4, formed by oxidation, reacts on the carbon of the pig iron, producing carbonic oxide, which, on escaping, agitates the bath of metal, and thus tends to make it uniform in composition. When the whole is melted a test is taken, and when the metal shows a proper fracture and toughness, as well as the right degree of decarburisation, it is run into a ladle and cast into ingot moulds, as in the Bessemer process. This method of working is possible only with the best pig iron, so that the usual plan is to decarburise completely, and then to add spiegeleisen or ferro-manganese. The latter containing more manganese than the former, a smaller quantity is required for deoxidation, and as, therefore, less carbon is added, a milder steel is produced.

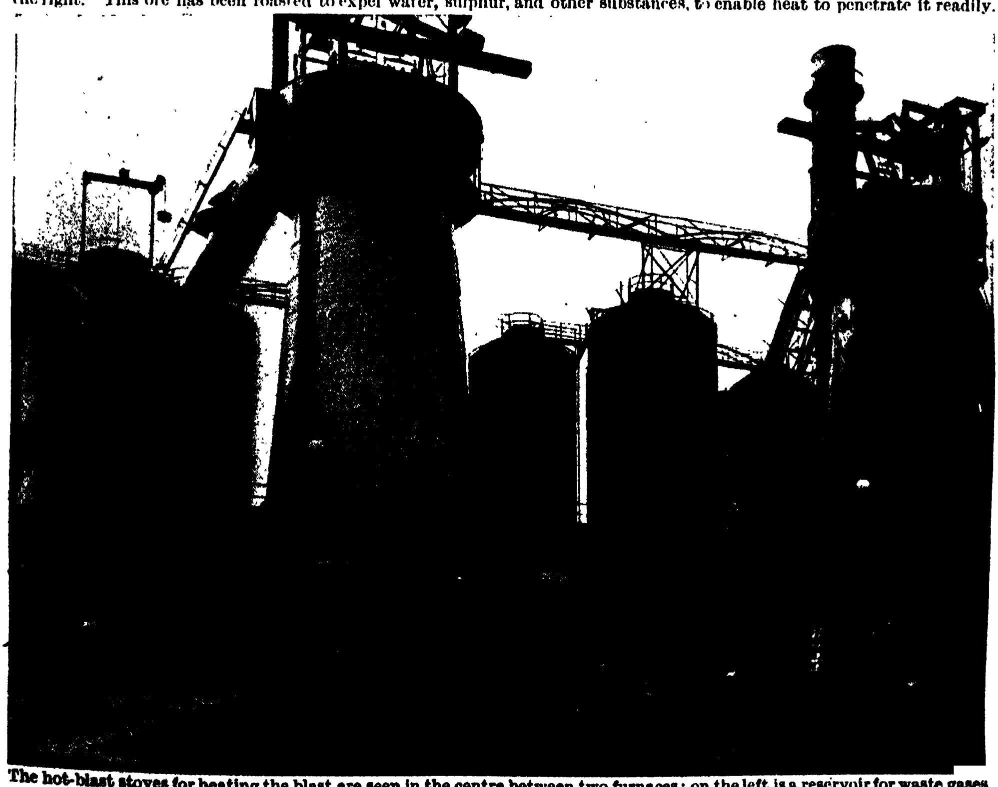
A few minutes suffice to melt the manganese alloy, during which the metal is rabbled, or stirred, to mix it thoroughly, after which the metal is ready for teeming into the mould. The tapping is effected by driving a pointed iron bar through the tap-hole into the bath of metal, and on withdrawing the bar the metal flows out and is followed by the slag. When the slag begins to flow the spout is taken away, and it is allowed to flow into a space prepared for it in the front of the furnace, that remaining on the hearth being removed by tools introduced through the working doors, which are on the opposite side of the furnace.

The Siemens-Martin Process. The Siemens-Martin process is similar to the above in operation. Pig iron is first charged in, and the requisite amount of steel scrap added. The proportion of scrap varies in different localities, depending on the quality of the pig iron and of the scrap procurable. With good hæmatite pig iron, about 70 per cent. of scrap is used, but in other cases it may be as much as 80 per cent. Heavy scrap is preferred to light scrap, being more readily handled and less liable to oxidation during the melting. If much oxide be formed on the bed of the furnace, it corrodes the lining. For convenience in charging, the pig iron is generally broken up into half pigs, and these are charged by hand through the furnace door with the *peel*, so as to distribute the charge evenly over the entire bed. In large furnaces the charging is done through two or three doors by men working with a peel at each. When the charge is thoroughly melted, Spanish or African hæmatite is added in lumps at intervals for the decarburisation of the metal. In this way, during the working of a 10-ton charge, 30 cwt. to 35 cwt. of ore will be added, each addition being followed by a state of violent ebullition of the metal on the hearth. Samples of the metal are taken for testing the malleability and toughness, and when the requisite purity is attained, the metal is allowed to stand for a short time to clear itself of slag, and small quantities of limestone are added during the process if the covering of the slag be insufficient.



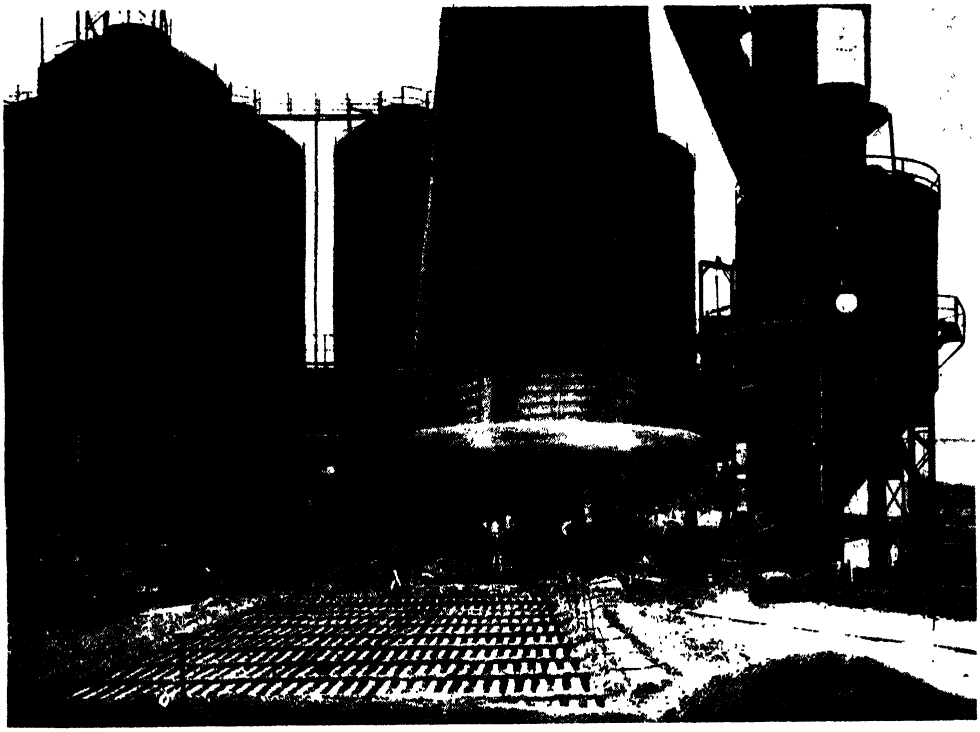


The two left-hand pictures show iron-stone being transferred from railway trucks to the inclined hoist of the blast furnace on the right. This ore has been roasted to expel water, sulphur, and other substances, to enable heat to penetrate it readily.



The hot-blast stoves for heating the blast are seen in the centre between two furnaces; on the left is a reservoir for waste gases conveyed by a pipe from the furnace top. These waste gases heat the blast in the stoves, and are cleaned to drive gas-engines.

PROCESSES IN THE MAKING OF PIG IRON



The base of a blast furnace is shown here encircled by the horseshoe blast main which supplies the tuyeres of the furnace. In the foreground is the pig-bed of sand moulds in which molten iron from the blast furnace sets into solid bars or ingots.

Molten iron reduced from ore is being tapped from the furnace and running out into the pig-beds shown above.

The injurious slag, made by union of earthy matter with the limestone used as a flux, is being tapped from a furnace.

THE BESSEMER CONVERTER IN FULL BLAST

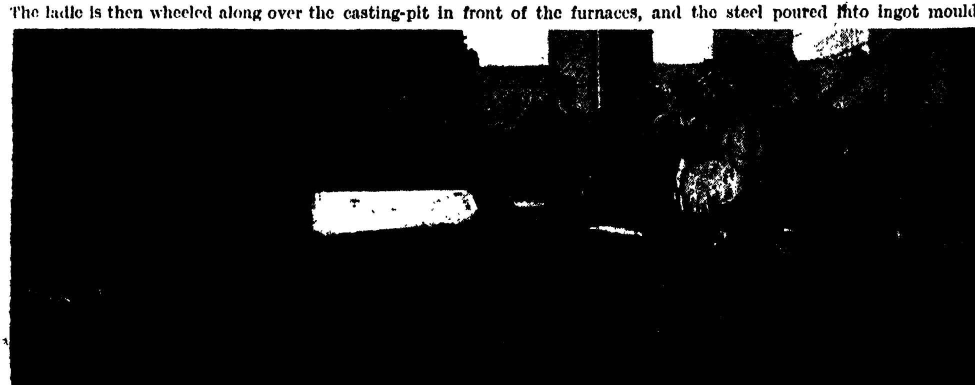
In the Bessemer process of manufacturing steel, bars of pig-iron are first melted in a cupola furnace, and then poured through a spout, as shown here, into a Bessemer converter, turned down into a horizontal position to receive it.

The Bessemer converter is then turned up, and an air-blast supplied at a pressure of from 18-25 lb. per square inch is forced through holes in the bottom, and up through the molten metal for twenty minutes. A roaring flame rushes out, at first a faint yellowish-red, changing to a dense yellow, the period of the boil, and dies away as a pale rose or amethyst tint.

A FIERY STREAM THAT FLOWS LIKE WATER

The steel which is made from the decarburised pig-iron in the furnaces is tapped, while molten, into a huge ladle.

The ladle is then wheeled along over the casting-pit in front of the furnaces, and the steel poured into ingot moulds.



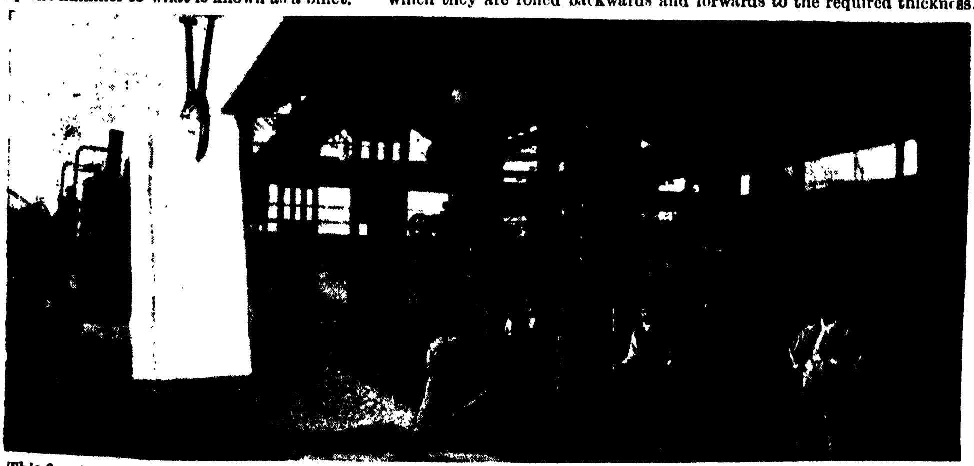
The ingots are taken cool from the mould and reheated, as in the Bessemer process, and one of these is here being drawn white-hot from the furnace to be hammered into billets or rolled into bars and sections for various industrial purposes

THE HAMMERING AND ROLLING OF STEEL

This picture shows the preliminary stages in the shaping of a white-hot steel ingot which has been brought straight from an ingot mould or a reheating furnace and placed under the Nasmyth steam-hammer.

In a brief space of time the ingot is reduced by the hammer to what is known as a billet.

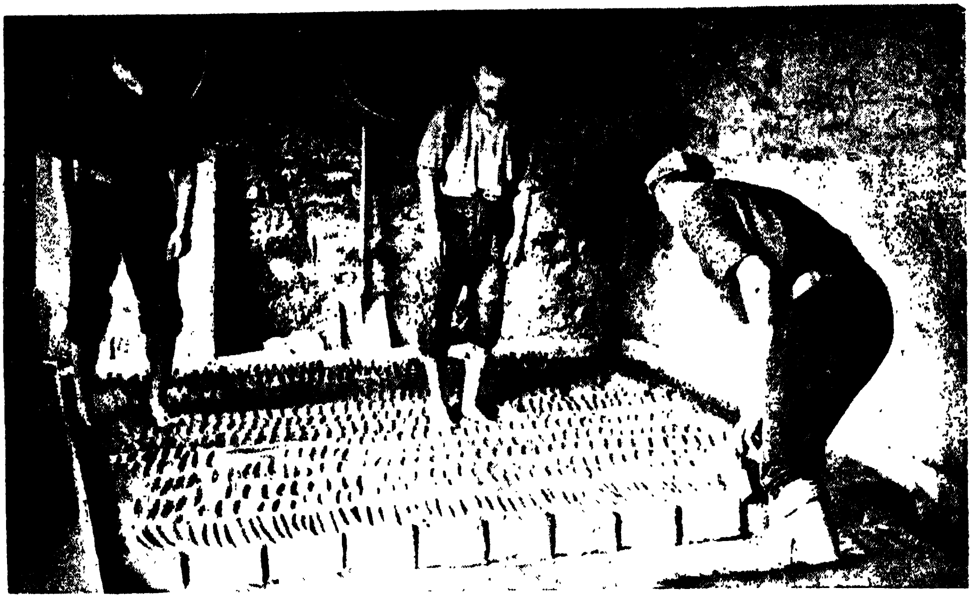
In the making of steel rods, heated billets are placed in a rolling-mill, in which they are rolled backwards and forwards to the required thickness.



This five-ton, white-hot ingot is being raised from a gas-fired soaking-pit. It will be rolled into slabs and other forms.

The photographs on these eight pages were specially taken by courtesy of the Park Gate Iron and Steel Company, Park Gate; Messrs. Brown, Bayley and Co., Sheffield; and Messrs. Andrews, Toledo Works, Sheffield.

THE MAKING OF STEEL IN CRUCIBLES



This picture shows one of the few cool operations connected with the manufacture of steel. Workers are treading the clay, from which are formed the crucibles or pots in which crucible steel is made. This method is more common in Germany.

The operation of pouring into a mould molten steel from a couple of crucible pots which have been taken out of a furnace is shown here. The rows of crucible pots, which are to be noticed on the shelves, are being seasoned for future use.

Spiegel or ferro-manganese, or a mixture of both, is added to remove oxygen and give the requisite amount of carbon. The duration of this process is longer than the scrap process, and the hearth is more strongly attacked by the ore.

When the charging is complete, the heating goes on for twenty minutes, when the valves are reversed, and so on till the charge is melted. On the addition of ore, the boil begins, caused by the evolution of carbonic oxide, due to the action of the oxide of iron on the carbon of the pig iron, and this continues till the iron is nearly decarburised. For dead soft steel, the carbon is reduced to 0·12 per cent., when the furnace is ready for tapping. Before tapping, it is usual to *pig back*, as it is termed, by adding a few half pigs to the bath of metal, so as to keep it well on the boil before the addition of the ferro-manganese. The operation requires about eight hours, and four hours for charging by hand and repairs.

After the charge has been tapped from the furnace, the tapping hole is made up with fire-clay and anthracite, and the bottom carefully examined for holes or cutting on the banks. These are repaired by spreading over them silica sand and glazing it in. It is then ready for the next charge.

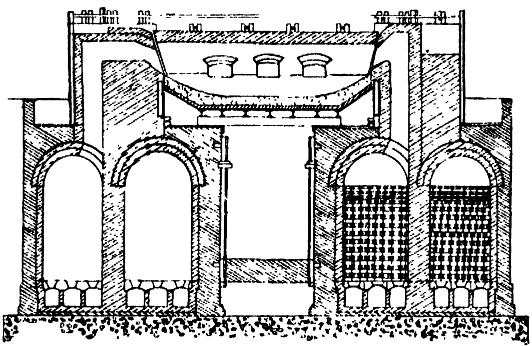
Acid Open-hearth Process. The acid open-hearth process does not remove phosphorus and sulphur from the iron, so that both increase relatively in the finished steel; hence the materials used must be low in phosphorus and sulphur. The silica should also be as low as possible, only sufficient, with the silica derived from the ore and furnace bottom, to form enough slag to cover the metal. The open-hearth process, like the Bessemer process, proceeds by first decarburising the bath of metal, and then by recarburising it by the addition of spiegeleisen, ferro-manganese, or other highly manganiferous alloy of iron, etc. The addition obviously introduces at the same time a small proportion of other impurities, such as sulphur, phosphorus, silicon, etc., into the steel; but the result is now minimised by the almost universal use of ferro-manganese as the recarburising agent, whereby a small weight of recarburising alloy is required for the introduction of sufficient manganese into the steel to prevent the red-shortness otherwise manifested by the metal, and to improve its malleability, without at the same time introducing too much carbon and such impurities as attend the larger amounts of spiegeleisen required. The use of ferro-manganese is specially necessary in the production of soft or mild steel. One advantage of the open hearth is that the steel can be quite dead melted, the process not being limited as to time, since the nature of the flame and the temperature of the furnace are so fully under control that the bath of fluid metal, after having been reduced to the lowest degree of carburisation required, may stand unaltered for any reasonable time, during which samples may be taken for testing, and additions of pig iron, wrought, scrap, spongy metal, or iron ore made so as to adjust it to the desired temper and quality, while spiegeleisen or ferro-manganese can be added in the solid condition in the required proportion immediately before casting, with the formation of a steel of which almost the exact composition is known beforehand.

In the open-hearth methods of producing steel the decarburisation and the separation of silicon and manganese from the pig iron of the charge do not appear to progress with the regularity which occurs in the Bessemer converter. During the first period of melting down of the charge in the Siemens furnace, the carbon, silicon, and manganese are more or less oxidised, so that at the end of this stage—the proportions vary with the temperature of the furnace—part of these elements have been removed. After the charge is melted down, however, the metal remains tranquil in the bath, undergoing little, if any, decarburisation, until the whole of the manganese has been oxidised, and the silicon in the metal has been reduced to about 0·02 per cent. This condition is obtained in from three to four hours, after which the bath of metal begins to boil from the escape of carbonic oxide resulting from the oxidation of carbon, and this state continues till the carbon is reduced to about 0·1 per cent., or less, at which point the bath again becomes tranquil, and the slag, which was, thirty minutes previously, of a brownish colour, begins to blacken, owing to the slight oxidation of iron.

The oxidation of the metal after melting depends on the composition of the slag and the temperature of the furnace. The variation in silica and oxide of iron directly after melting and just before tapping is comparatively small, but the amount of oxide of iron increases after the addition of the ore. This, however, is soon equalised by the taking up of fresh silica from the lining of the hearth. If the slag be thin, due to a low silica content, the oxidation of silicon and manganese in the pig iron is comparatively rapid; but if the slag be thick, or highly siliceous, the silicon and manganese are not removed, and may actually be reduced from the slag and pass back into the metal. With a very siliceous pig iron, a rich gas, and rapid draught, the temperature gets too high, the carbon is oxidised in preference to the silicon, and the decarburised iron is too high in silicon. Hence, while it is essential to have sufficient heat to maintain a fluid bath of metal or slag, the temperature must be regulated so as not to exceed a certain limit.

Recarburisation of Iron. In the early days of the process, the successful recarburisation of iron with free carbon was found to be impossible, owing to the imperfect knowledge of the effect of temperature on the oxidation of carbon. Both liquid and gaseous carburising materials were tried, but with little success, and the workers had to fall back on spiegeleisen and ferro-manganese as carburisers. But these are far from pure substances, and introduce impurities into the iron. When the microscope began to be practically used in the examination of metals, it was found that manganese did not alloy so readily with iron as had been assumed,

and, if not thoroughly mixed with the iron, it had a tendency to segregate. This explained many mysteries in the curious fractures of steel, and the addition of manganese was reduced to the quantity required for deoxidation. The basic Bessemer process especially led to a product comparatively rich in oxygen on account of the after-blow; therefore a larger amount of manganese was required to remove it, and this manganese prevented the production of high carbon steel unless such manganese was left in the steel. Efforts were therefore made to recarburise the iron without the addition of manganese alloy. If the deoxidation were effected in part by spiegeleisen, and completed by the addition of aluminium, only mild steel could be produced. Darby then introduced the use of free carbon for this purpose. In adding the carbon there is no marked change in the other elements, and as the carbon is added to the charge in the ladle, there is no reduction of phosphorus from the slag.



14. SECTION OF SIEMENS OPEN-HEARTH FURNACE

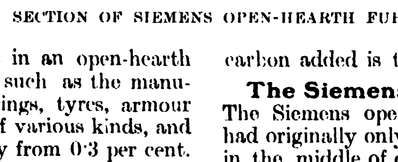
Medium carbon steels are now readily made in an open-hearth furnace for many purposes, such as the manufacture of axles, guns, springs, tyres, armour plates, wires, steel castings of various kinds, and tools. The carbon may vary from 0·3 per cent. to 1·2 per cent. There are three distinct methods of making such steels in an open hearth:

1. To work the charge of pig iron until it has reached the desired amount of recarburisation, and then tap out.

2. To work the charge until it is completely decarburised, and add spiegeleisen or ferro-manganese for recarburising.

3. To work the charge as in the former case, and recarburise outside the furnace by the Darby or some similar process.

For steel with about 0·3 to 0·6 per cent. of carbon the first method is often adopted, but for best qualities the second method is preferred. The ferro-manganese may be added, either in the furnace, immediately before tapping, or to the metal as it runs into the ladle. For steels with 0·7 per cent. of carbon and upwards, satisfactory results cannot be obtained by simply working down to the desired carbon content, and then tapping.



15. PLAN OF SIEMENS OPEN-HEARTH FURNACE

The third method, then, gives the best results. [See Harbord's "Steel," page 171.]

Mr. John Darby has advised a method of recarburisation by pouring iron through a tube perforated at the bottom and containing carbon, from which the carburised iron runs into the ladle. It was found that the absorption of carbon by the iron was so rapid that the lengthened time required by the above method of filtration was unnecessary. The next plan was to run into the filter vessel a stream of carbon particles at the same time as the metal was teemed into it. It was found that sufficient carburisation occurred during the teeming of the first third of the charge. The employment of the carburising vessel was afterwards found to be unnecessary, and now in similar processes it is customary to throw into the ladle at intervals a definite quantity of finely divided carbon. By this means considerable economy is effected, due to the saving of spiegeleisen or ferro-manganese. In some American works dry crushed coke, in paper bags, each holding about 50 lb., is thrown into the ladle with the decarburised metal, the first bag being thrown in as soon as the metal covers the bottom of the ladle. The accuracy of the metal will be understood when it is stated that out of twenty-four cases the carbon varied only 0·02 per cent. About half the carbon added is taken up by the iron.

The Siemens Open-hearth Furnace. The Siemens open-hearth furnace [**14 and 15**] had originally only one working door, which was in the middle of one of its longer sides, but in the larger modern furnaces there are three doors. On the opposite side, and at the lowest portion of the hearth, is a tapping hole, and a channel through which metal is conducted for casting. The horizontal section is a rectangle with the corners removed. The hearth is composed of refractory sand, supported on an iron bottom, kept cool by a current of air, and it is repaired after each operation. The old type of furnace has the hearth built over the regenerators, using the regenerator arches to support the furnace. This method is now practically obsolete. The regenerators are kept well to each end, and the body of the furnace is carried on steel girders, quite independent of the regenerator arches, so that the air can circulate underneath, and in case of the metal breaking through the bottom there is no danger of its getting into the regenerators. The roof and walls of the furnace are lined with silica brick. The body of the furnace is encased in steel plates, well riveted together and strengthened by supports and tie-rods. The gas enters the furnace through two openings, termed the *ports*, and the air through three similar ports, all arranged side by side. The blocks containing these ports must be capable of resisting a high temperature and the consequent

expansions and counter actions, hence they are made with air-cooled hollow castings. The position of the ports is designed to give a perfect mixture of gas and air on entering the hearth, so as to ensure a complete and rapid combustion. The position of the ports depends to some extent on the contour of the roof. In some high-roofed furnaces, dome-shaped alternating arches, or gallery ports, are used for gas and air. It has been found with sulphurous fuels that the metal is less liable to take up sulphur during the melting when gallery ports are used. It was customary in former years to build the roof with a strong slope from each side to the centre, so as to deflect the flame on to the bath of metal, but it was found to be rapidly burnt away, and in all modern furnaces the best results are obtained with a fairly high roof, the inclination of the gas and air ports being sufficient to plunge the flame on to the metal.

The regenerators are chambers filled with a checker work of refractory brick, arranged so that brick and air spaces occur alternately. The air chambers are generally made longer than the gas chambers, but the chief thing is to have sufficient capacity. The chambers should be 15 ft. to 20 ft. deep, and the capacity of gas to air regenerators in the proportion of 1 to 1·4. In all regenerative gas furnaces much fine dust is carried over mechanically with the gases, and tends to choke up the spaces in the checker brickwork. In large furnaces especially, it is advisable to have a supplementary chamber between the ports and regenerators to serve as a dust-catcher.

Basic Open-hearth Process. The object of this process, like that of the basic Bessemer process, is the removal of phosphorus from the iron by means of a basic or neutral lining, and the addition of lime during the working. Several special furnaces have been devised for this purpose, but the ordinary furnace as used for the acid process gives equal if not better results.

A special type of furnace on the Batho principle was devised by Dick and Riley for use with the basic process. It has a circular or oval body, with a steel casing. It is placed on a platform supported by girders, and left entirely clear underneath, so that the bottom is kept cool and the lining better preserved. The four regenerators form four circular towers, and, instead of being situated below the bed of the furnace, are placed in pairs at opposite sides of the furnace. Each regenerator forms a separate structure, which is out of harm's way in case of the metal breaking out, and as it has only its own weight to carry, it cannot get out of shape. It is very desirable to regulate the amount of gases passing through the regenerators, in order to control the relative amounts of heat stored up in these chambers. The tendency is for the gas chambers to receive the largest amount of waste heat, whereas the air chamber should be the more highly heated of the two. The regulation is affected by the adoption of a new kind of disc valve.

The regenerators are 6 ft. 6 in. internal diameter, lined with 9-in. firebrick, and have outside casings of $\frac{3}{16}$th in. steel plates. The Batho method of arranging the flues has been adopted, the distinctive points of which are that the gas and air ways are brought up outside the furnace instead of inside, as in the ordinary Siemens furnace. In the latter form the expansion and contraction disturbs the brickwork, causing cracking, which leads to the mixing of the gas and air before entering the furnace ports. In the Batho type the external arrangement of the flues simplifies the furnace itself, reducing it to a simple box, which may be readily lined by ramming in material, or by brickwork. The ports are of the Hackney type, the air-port being placed vertically, or nearly so, above the gas-port, so that the two streams directly unite, and are not deflected as in the Siemens type.

The roof is dome-shaped, as in the Siemens radiative furnace, but it is not used for the purpose of radiating the heat of the flame, as the flame is thrown directly upon the material to be heated. The roof can be made movable, so as to introduce large pieces of scrap.

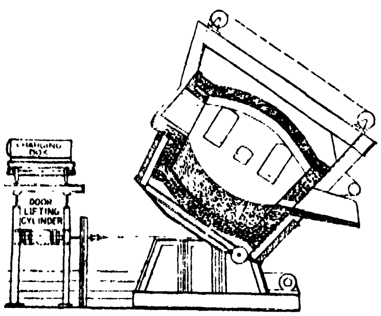
The roof is carried independently of the sides, and is built with silica bricks. The sides up to the top of the door and the gas-ports are of basic material. The acid section, however, does not rest upon the basic lining, a space being left between them, although acid and basic materials may touch provided one does not impose weight on the other. The basic lining is burnt dolomite mixed with tar, as in the basic Bessemer process, described on page 927.

Bertrand-Thiel Process. This consists of the use of two open-hearth furnaces used in conjunction, one termed the *primary*, and the other the *secondary* furnace. The upper, or primary furnace may be situated at a higher level than the secondary furnace, and is used for melting and partly refining common pig iron. The larger, or secondary furnace is placed at a lower level, in which the partly refined iron, together with all the scrap available and some ore are melted, and the iron completely refined. When working with a large proportion of scrap the furnace hearths need not be kept so deep—that is, they may have less cubic capacity for a given weight of charge than when working with pig iron alone, as in the latter case greater additions of lime and ore are necessary. Moreover, when pig iron alone is used, the charge boils up excessively, and may cause the slag to flow out of the working doors, so that some scrap is advisable to quiet down the metal. Silicon and manganese are practically eliminated in the first furnace, together with some phosphorus and carbon. About two-thirds of the carbon and one-third of the phosphorus are left, to be removed in the finishing furnace. It will be seen from the above remarks that if it be attempted to urge the rapidity of decarburisation in an ordinary single open-hearth furnace, the slag will rise so rapidly as to run out of the doors of the furnace. The greater rapidity of working in the duplex method is due to the fact of the impurities being slagged off in two stages, hence there is less slag present and more room for the metal. In the lower hearth the metal, which has been largely

freed from sand and slag forming elements, only causes a limited amount of slag to be produced.

In an ordinary open-hearth furnace the oxidation of the charge is chiefly confined to the upper part, where it is in contact with the overlying slag and the lumps of ore, but in the Bertrand-Thiel process the hot metal from the upper furnace is run on to white-hot scrap which has become strongly oxidised, so that the oxidising influence is both at the top and the bottom, and the metal is therefore more quickly purified. Moreover, at the high temperature of the Siemens furnace there is a violent reaction between the metalloids and the oxide of iron, and great internal heat is produced by their oxidation, which greatly assists in maintaining the temperature of the furnace. A basic lining appears to be necessary, and this lining in the preliminary furnace to a large extent contributes to the success of the process.

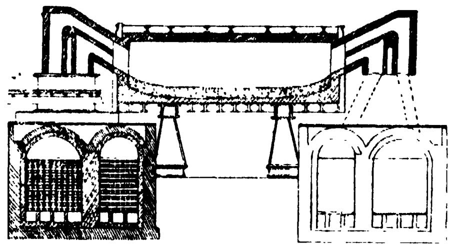
Talbot Process. This is a continuous open-hearth process conducted in a tilting furnace with a basic lining. The furnace is specially designed so that any quantity of slag and metal can be poured off at any period during the working of the charge. The method of working as explained by the inventor is as follows. The pig iron used has the composition—carbon, 3·76; silicon, 1·0; sulphur, 0·06; phosphorus, 0·90; and manganese, 0·40 per cent. This is melted in a cupola. Suppose the furnace to be charged on a Sunday night with 50 per cent. molten cupola metal and 50 per cent. scrap. This is worked in the usual way for steel. When the charge is finished, about one-third—20 tons—is poured off into the ladle and cast into ingots. No slag is run off with this portion of the steel. Oxide of iron in the finely-divided state is then thrown on to the slag, and as soon as it is melted about 20 tons of cupola metal are run in to replace the steel tapped off. An immediate very active reaction takes place, during the continuance of which the gas is cut off from the



17. WELLMAN FURNACE—CROSS SECTION

furnace. Carbonic oxide is copiously evolved, and after the boil has been on for 15 minutes the slag is poured off, and the bath of metal worked into finished steel by the help of fresh additions of iron ore and lime. Another 20 tons are again tapped off, and another similar quantity of cupola metal added as before. These operations are continued for a week, and the furnace completely emptied on Saturday.

The Wellman furnace used in the Talbot process [16 and 17] is a long, horizontal chamber, resting on the pair of racks, and rolling on them by means of the segments of an enormous pinion. The rolling motion is given to it by large, nearly vertical, hydraulic cylinders, and when tapping, the furnace is tilted forwards [17] so as to depress the tapping spout, through which the metal is poured. The rolling surfaces are



16. WELLMAN FURNACE—LONGITUDINAL SECTION

provided with rack work, which keeps the furnace parallel without supporting any of its weight. In order to tilt the furnace, water is admitted to the top of the cylinder. The gas and air ports are of novel construction. The two passages leading from the regenerators and the ports terminate in two water-troughs on the level of the charging floor. The brickwork of the ports is enclosed in a metal cage, but instead of being fixed it moves on flanged wheels running on rails, which enable it to be moved a few inches to and from the furnace end. When melting is in progress the ports are moved up to the surface, so that the face plates are in contact. When ready to pour, the ports are moved away. A special kind of ladle is also used, attached to the front of the tapping hole, and forming part of the structure. This ladle has two pouring holes and stoppers. When the furnace is tilted for pouring, the metal and slag flow into the ladle and stand at the same level as the metal in the furnace.

Trains of casting bogies, each containing two moulds, are then brought under the teeming holes of the ladle, and two moulds can be filled simultaneously. The regenerative chambers are arranged in pairs at each end of the furnace, and extend under the charging platform. The furnace top, side, and outer layer of the bottom are lined with silica and magnesite bricks. The bottom is made with magnesite. The air-reversing valves are of the usual butterfly pattern, and the gas valves consist of two mushroom valves. Both valves and seats are water-cooled. There are three charging doors, operated by pneumatic cylinders through wire ropes, the leads being so arranged that the doors are kept closed while the furnace is being tilted.

Metal Mixer. Many attempts have been made to use the liquid cast iron direct from the blast furnace for charging the Bessemer converter and the open hearth, but owing to irregularity in composition this has not been successful. If, however, the tappings from several blast furnaces are mixed together in a special receiver, the irregularities are neutralised, a certain

amount of purification takes place, and a large mass of a fairly uniform composition is obtained. The mixer may be of various shapes, but it is usually made of wrought iron or steel plates, lined with firebrick. It is mounted on trunnions and tilted by powerful mechanical gearing. In some works the mixer is of a semi-cylindrical form with hemispherical ends and an arched roof. It rests on rocker bands, and is tilted by a ram at one end. In other works the tilting open-hearth furnace is used simply as a mixer.

Charging Machines. One of the defects of an ordinary open-hearth furnace is the great amount of time and labour absorbed in charging the furnace by hand, and this has led to the introduction of machines for this purpose. The first machines were worked by hydraulic power, but these have been replaced by electrically-driven machines, of which that of Wellman is the most largely used. The materials are put into iron boxes [17], each holding 1 ton, which are picked up by the machine, pushed into the furnace, emptied, and withdrawn, the whole operation taking one minute, so that 50 tons can be charged into the furnace in about one hour.

Casting of Steel. In order to get sound, forgeable ingots of steel, great care is necessary to avoid blowholes, segregation, and piping. For this purpose a *dead melt* is necessary—that is, to finish with a good, thick, clean, non-oxidising slag, which must be at the same time fairly fluid, to prevent it entangling some of the metal.

Fluor-spar added to the metal in the ladle gives good results. The gases in steel are principally hydrogen, nitrogen, and carbonic oxide, and these are likely to increase with the rising temperature. The presence of silicon and manganese tends to keep these gases in solution, and thus to prevent unsoundness. Aluminium is generally added to the metal in the ladle for the same purpose. The amount of silicon, manganese, or aluminium should be limited to the quantity required for absorbing the gases, otherwise the excess alloys with the steel and injures its qualities as well as tending to promote segregation. A steel casting is very liable to have internal stresses, caused by unequal contraction on cooling. The amount of shrinkage varies from 1·5 per cent. to 2 per cent., according to the composition and temperature of the metal. The softer and hotter the metal the greater the shrinkage.

Annealing of steel castings is very important, in order to remove the stresses set up in solidifying, and thus to toughen the metal. The proper annealing of large castings takes nearly a week. Different articles require different amounts of carbon. Steel for pinions and hammer dies requires 0·6 per cent. of carbon; miscellaneous gearing, from 0·4 per cent. to 0·6 per cent.; general machinery castings, less than 0·4 per cent.; and castings subject to great shock should not contain more than 0·2 per cent. Hulls and gun-carriages contain from 0·2 to 0·3 per cent. of carbon. Steel castings to stand the same stress as iron need only to be two-thirds as heavy if they are large. Steel is now taking the place of iron in gearing, hydraulic cylinders, engine cross-heads, pistons, rolls, spindles, coupling boxes, hammer heads, dies and castings for ships.

Treatment of Steel Ingots. Steel is not piled like iron for reheating, but cast into ingots of the proper size for the production of the required bar, plate, rail, etc. The hot ingots are usually conveyed from the moulds to a reheating furnace, and were formerly extended by the steam hammer before rolling; but this is now considered objectionable, and they are therefore passed directly through the *cogging* or roughing rolls, then reheated and rolled in the finishing rolls to the required section. For small rails, the blooms after cogging may be finished right off without reheating, being rolled in long lengths and then cut into rails of the required length by a circular saw. This reduces the amount of waste from the crop ends, as a fewer number of rough ends require to be cut off than when the rails are made in short lengths.

Soaking Pits. Instead of using a reheating furnace the sensible heat of the ingots may be utilised by placing them in hot pits built of masonry. The ingot of steel is removed from the mould as soon as it is sufficiently solidified, then placed in the hot pit and closely covered. By this means the heat given out by the metal is absorbed and stored up in the brickwork. In about an hour the ingot will be at a uniform temperature throughout, and sufficiently hot for rolling. During the soaking process a quantity of gases is liberated from the metal, consisting of hydrogen, nitrogen, carbonic oxide, etc., thus excluding the air and preventing oxidation. If the brickwork becomes overheated, it may be cooled by dropping in some coal, when the surplus heat is absorbed in decomposing the coal and in volatilising the products. Considerable economy is claimed for this mode of working, as the loss of metal by oxidation during reheating, together with the expenditure of fuel, is largely avoided.

If, however, the output be insufficient to keep the pits occupied, and considerable intervals of time elapse between the heats, the pits lose too much heat, and the ingots get cold. In such a case the pits are generally heated by gas.

Steel Rails. The essential properties in a rail are hardness and toughness, which do not generally go together. If the metal is not hard enough the wear will be too rapid, due to the constant abrasion to which it is subjected, and if too hard it is liable to be brittle and fractured by the sudden shocks which occur by trains running at high speeds over it. However, rails are now made harder (that is, higher in carbon) than formerly. A medium hardness is therefore best, as it gives a good life to the rail without the great liability to crack which harder steels possess. In order to compensate for the increased brittleness of the harder rails now in use, the weight has been increased from 56 lb. or 80 lb. to 84 lb. or 100 lb. per yard. The smaller figures are for rails for small lines, and the higher figures for rails for main lines.

Defects of Rails. One of the chief causes of brittleness in rails is the presence of too much phosphorus in the steel. Phosphorus generally raises the elastic limit, and thus the elastic ratio, which is an index of brittleness. An illustration of the vagaries of phosphorus in steel rails may be given in the case of weld-iron rails, which may have as much as 0·45 per cent. of phosphorus and yet stand a severe impact test without breaking, while steel rails with 0·3 to 0·4 per cent. of carbon and 0·15 per cent. of phosphorus are liable to break with a drop test of one ton falling through 6 in., so that anything above 0·1 per cent. of phosphorus is dangerous. In fact, the behaviour of phosphorus is so capricious that it is better absent altogether. Silicon is another element which tends to promote brittleness, and this should, therefore, be low. The higher wheel-loads now used on our large railways require that the rails should possess greater hardness, or the ends are liable to be crushed. The carbon is now increased to 0·5 per cent., the manganese to 1 per cent., the silicon to 0·1 per cent., and the phosphorus below 0·1 per cent. If the carbon be increased to 0·6 per cent., as in the case of some American rails, the phosphorus and silicon must be present only in minute quantities, or the safety of the rails will be dangerously impaired. Mr. Sandberg, rail inspector of the Swedish State railways, found that 80-lb. rails with 0·6 per cent. of carbon flew into pieces with less than half the specified *tup test*, while those with 0·45 per cent. stood the test of a drop of one ton falling from a height of 20 ft. Sir Lowthian Bell considers that the fracture of rails is chiefly due to mechanical causes rather than to chemical composition.

Nickel Steel Rails. Nickel steel is now being used for rails in America with excellent results. The following table, by P. H. Dudley, gives the chemical composition of the rails furnished by the Carnegie Steel Company, which were made by the open-hearth and Bessemer processes as indicated.

Name.	Open Hearth.	Bessemer.	Bessemer.	Bessemer.
Nickel ..	3·52	3·22	3·50	3·40
Carbon ..	0·33	0·50	0·52	0·40
Silicon ..	0·05	0·13	0	0·11
Manganese ..	0·80	1·00	0	0·79
Phosphorus	0·14	0·09	0	0·09
Sulphur ..	0·02	0·03	0	0·04

The wear of these rails was very satisfactory. A report stated that since they were laid they had outworn two or three ordinary rails, and were then only beginning to show signs of wear. Some of the rails were, however, too hard, and in some breakages had occurred.

There are several distinct forms of wear and deformation of rails which must be due to the physical and mechanical properties:

1. Surface wear of the heads, due to the rolling loads. Surface wear from adhesion of the engines which draw the trains. Surface wear due to the application of breaks to retard or stop the trains. Surface wear due to sanding of the rails.

2. Oxidation of the surface of the rails.

3. Wear of the base of the rails on the cross-ties and under the spikes.

4. Wear and oxidation of the metal of the heads and bases of the rails at the fishing angles with the splice bars.

5. Wear and deformation at the joints.

6. Wear of the surface due to gradients, abrasion due to curvature, and distortion due to hollow wheel treads.

7. Large shearing stresses in the web of the rails, due to the rails riding the bolts.

So far as rails are concerned, the advantage of open-hearth steel over Bessemer steel has not yet been definitely proved, but whatever steel is used care must be exercised in making it, in pouring the ingots, in their handling and heating, and in the rolling and straightening of the rails. The new method of rolling has a tendency to prevent that care and supervision being exercised which was formerly bestowed when rails were made shorter and lighter.

Testing Rails. A rail, being practically subjected to a succession of blows in practice, is generally tested by a drop test. This consists of the weight of one ton falling through the distance of 15 ft. for a light rail, and 20 ft. for a heavy rail. For light railways in this country a rail weighing 56 lb. per yard is specified by the Board of Trade, a maximum load of 10 tons on the axle, and a maximum speed of 25 miles per hour. In order to test a rail for sufficient hardness, a short piece is laid on bearings about 3 ft. apart and the centre loaded with a weight of 10 tons to 20 tons, according to the weight of the section, under which the rail must show no appreciable permanent set, and there should be no undue deflection under a load of double this amount.

An American Rail-mill. A modern American rail-mill is arranged three rolls high, and consists of three or four separate mills, each driven by its own engine. This three-high system admits of two pieces being rolled in a stand of rolls simultaneously, and in such mills the grooves open upwards and downwards alternately, so that the rail does not need to be turned upside down between each pass, as in the reversing rolls. The hot ingots of steel as they come from the heating furnace or soaking pit are first passed through the blooming or roughing rolls. Here the steel receives a rough shape, and is then conveyed to the shears and cut into two pieces, one being used for a small rail, and the other for two larger ones. The large pieces are reheated, and pass to the finishing rolls, where the bars are made into finished rails. Before the final rolling the rail is taken to a cooling table, where it is allowed to remain until it has cooled down to a certain temperature (about 870° C.). This gives a fine grain

The smaller pieces to be converted into small rails are reheated in a furnace, and when sufficiently hot are passed in succession through three sets of rolls, each three high. The finished rails are cut into lengths 30 ft. long.

A. H. HIORNS

Pass Books. Paying-in Books. The Cash Account. Improved Form of Cash Book. Petty Cash Records. The Imprest System.

BANKS AND CASH

An allusion has already been made to pass books. First let us note that the pass book is generally recognised as the *customer's* book. That being the case, lodgments are entered on the debit and cheques on the credit side thereof, and the two sides harmonise with the two sides of the customer's cash book. Occasionally, however, the sides of the pass book are reversed so as to correspond with the customer's account in the bank ledger, where lodgments must appear as credits, and cheques paid as debits.

A Rare Pass Book. There is a third form of pass book—but this is more rarely met with—which has the usual columns for debit and credit entries, and a balance column besides. In the latter is shown the effect of each operation upon the banking account. That is to say, the pass book is balanced, item by item, but the balances are relegated to a special column or columns, and are not allowed to interfere with the continuity of the entries in the remaining columns of the pass book.

Next to be considered are the documents used in connection with a banking account. The chief of these are the "paying-in" slip and the cheque. The former is used when a lodgment is made. It shows for whose account money is paid in, the date, and the sum total, and tabulates the items comprising the lodgment, as bank-notes, gold, silver, and copper, town cheques—country cheques being paid in on a separate slip—postal orders, and so on.

Crossed Postal Orders. Postal orders received by a person possessing a bank account are often treated as "crossed" cheques. If not already crossed by the senders, they are crossed by the receiver, who draws or stamps two parallel lines across the face of each order, with or without the addition of "& Co."

The effect of both crossings is exactly the same—namely, that payment can be obtained from the Postmaster-General only through a banker acting on behalf of a customer. But while a cheque to order requires endorsement, and a postal order cashed for a private person must bear the signature of the payee, a postal order presented for payment through a bank needs neither endorsement nor signature of the payee.

When two or more postal orders are lodged at the bank, the total amount is entered on the town pay-in slip, and the details on a supplementary slip for the use of the bank.

"Paying-in" Books. Banks in England supply paper-bound books of pay-in slips to their customers. Each slip has a counterfoil. Particulars of the lodgment are entered on the counterfoil and repeated on the slip. The dividing line between the counterfoil and the slip is perforated, so that when the paying-in book is presented with the lodgment to the bank teller he may, after satisfying himself that all is in order, easily detach the slip from the counterfoil. The latter he initials, and hands back the paying-in book to the person who presented it, retaining the slip to be dealt with by the bank.

In Scotland the counterfoil paying-in book is dispensed with. The customer merely enters the items of the lodgment on the pay-in slip, which he presents with the money and his *pass book*. Instead of initialling the counterfoil of the paying-in book, the teller, after verifying the slip, enters the amount in the pass book, in words as well as in figures, and initials the entry. The book and slip are handed back to the customer, who presents them to the cheque clerk. The latter compares the entry with the slip, initials the entry, and returns the pass book to the customer, retaining the slip to be dealt with by the bank.

Cheques Paid by the Bank. The other side of the pass book is concerned with cheques paid by the bank. In England, these are entered by the pass book clerk. In the metropolis, paid cheques are placed in the pocket of the pass book, and thereby reach the customer the next time he calls for his pass book from the bank. In Scotland, the customer himself enters the cheques in the pass book, and leaves the book with the bank now and again, so that his entries may be verified. In England, the pass book is in the bank's custody the greater part of the time, being withdrawn at intervals; in Scotland it is seldom at the bank for any length of time, being required by the customer almost daily. By virtue of the system explained above, the Scottish pass book tends to become a copy of the customer's cash book rather than a copy of the customer's account in the bank ledger. Hence it is necessary, before striking the periodic balance in the pass book, to carry forward to next account all entered cheques which have not yet been presented for payment.

The Cash Account. The cash account, the source of whose entries was the journal, is now no more, its place having been taken by the cash book—an original register of receipts and payments. But the primitive *form* of the cash account is frequently perpetuated in the cash book. Two money columns, one on each side of the cash book, doubtless suffice for the entry of receipts and payments by traders and others who do not avail themselves of banking facilities; but when money is received and paid

by the bank, the single debit cash column and the single credit cash column will be found inadequate to modern requirements. The most scientific method yet devised for recording cash and bank transactions has already been explained. But that method cannot succeed unless the rule as to lodging intact all moneys received from outside sources is rigorously enforced.

On various grounds some business men maintain they cannot adopt this system in its entirety. They are willing to pay into the bank all cheques received, and so much of the cash as may not be required for the till (petty cash), but they object to lodge all moneys without deduction as and when received. In such cases the method usually adopted is to enter in the bank column on the debit side all cheques received. All receipts other than cheques are first entered in the cash column on the debit side, and, as lump sums are paid into the bank, the amounts are entered in the cash column on the credit side and in the bank column on the debit side, because they are both payments out of cash and receipts by the bank.

The rule is here to bank daily round sums of cash and all cheques received, but if a received cheque, instead of being banked, were to be paid away again or cashed, it would be treated as coin, and entered in the "cash" column.

Petty Cash. There are two ways of treating the petty cash book. By some it is regarded as a mere memorandum book in which to enter day by day, or whenever the notion seizes them, payments which are considered too insignificant for individual entry in the cash book. At the end of each week, month, or other period, these payments are summarised, and the summary figures carried to the cash book. Thus, assuming that for a given week certain trade expenses totalled £1 11s. 2d., the amount is shown on the credit side of the cash book, and the details are noted in a memorandum book as follows:

1904			
Aug.. ..	Stamps		5
	Fares, West End		
	Gratuity to carman ..		
	Book of telegram forms ..		10
	Blotting paper		1
	String		
	Crate wood for cases ..		7
	Advt. in P.O. Directory ..		5
	Carr. on goods from Lebus		1
		£1	11

Petty Cash Items. This method of recording petty cash expenditure is an improvement upon the former practice of passing petty cash items through the journal. There is, however, a serious objection to the memorandum petty cash book. It constitutes a weak spot in any system of bookkeeping, because it is not properly interlinked with the other counting-house records. Books of original entry are temporary halting-places for items on their way to the ledger. It is here that transactions and transfers have debit and credit values assigned to them, and these values must be passed to their final resting-place in the ledger.

The penalty for default is that the ledger will not balance, and a not less serious consequence is that the ledger will be destitute of information which it ought to contain. Hence the regular admission of items into a journal is in itself a sort of guarantee that they will find their way in due course to the ledger. If they are posted wrongly, or not posted at all, the two sides of the ledger will fail to agree, search will be made for the difference, and errors and omissions will be laid bare.

Memorandum Petty Cash Book. The memorandum petty cash book is not a book of original entry in the technical meaning of the term. It bears the same relation to the cash book—the real book of original entry for the item of £1 11s. 2d.—as the waste book does to the journal. Its entries may affect the ledger indirectly because of the difficulty of verifying the cash balances if they were not taken into account, but in practice the keeping of a memorandum petty cash book too often resolves itself into an attempt, or a series of attempts, to overcome the hiatus between the amount of cash that ought to be in hand according to the cash book and the amount actually present in the cash-box. The cashier is in truth the victim of a complicated system of dealing with the cash and of recording cash transactions.

Not only is it very easy under such conditions to lose sight of, or to forget to note down, an item in the memorandum book, but there is a temptation to "lump" together items which really belong to different accounts. The correct allocation of petty items is a tedious and may seem a trivial task, in view of the smallness of the weekly or monthly totals. Nowadays, however, the margin of profit is so narrow, and competition so keen, that it becomes imperative to analyse expenditure exhaustively, so that waste and extravagance may be detected and for the future prevented. Let us see, for example, how the distribution of petty expenditure would be made in the case before us.

A summation of the items in the memorandum cash book for the week ended August 6th, 1904, would be made. Then the total of £1 11s. 2d, would be apportioned as under:

	£	s.	d.
Postage and telegrams		15	2
Packing materials		7	10
Carriage		1	6
Advertising		5	0
Printing and stationery..		1	0
Trade expenses		0	8
	£1	11	2

Instead of entering one item of £1 11s. 2d. in the cash book, we should now enter six items aggregating that amount, writing opposite each item the name of the account to which it belonged. Finally, the items would be posted to their appropriate accounts in the ledger.

Trade Expenses. It may be stated in passing that Trade (or Office) Expenses account is an account of miscellaneous items, trifling in amount and of infrequent occurrence. The total amount standing to the debit of Trade Expenses account at the end of a given period represents,

in fact, a residuum of expenditure which cannot fairly be charged to specific expense accounts, having been incurred for the benefit of the business as a whole.

The petty cash book is too frequently looked upon as a record of items which are too insignificant to be passed through the cash book. That may have been so originally, but today we find the petty cash book performing the functions of a true cash book—items appearing therein of salaries, wages, commissions, travelling expenses, which represent quite respectable sums of money, as well as items of genuine petty expenditure.

The Imprest System. Let us now briefly consider one or two of the other methods of recording petty cash transactions which are in use at the present time. First, there is the imprest system. The petty cashier receives an open cheque for a round sum of, say, £10, which amount the cashier enters on the credit side of the cash book, charging petty cash account therewith. Presently the ledger keeper opens an account for petty cash with the debit of £10 posted from the cash book. The petty cashier having cashed the cheque, puts the proceeds in the cash-box. From the fund thus provided he makes payments not exceeding the authorised limit for any one payment. At the end of the month—or earlier, should his balance happen to be running low—he totals the payments made since he received his latest advance, and rules the amount off thus :

1904 Jan. 1 etc.	Stamps .. .. etc.		5 etc.	
	Total for January	£8	14	3

His next care is to analyse the total; which done, he takes his analysis, together with vouchers in support of his expenditure, to the cashier, who examines the figures with the vouchers, and, finding them correct, in due course hands the petty cashier an open cheque for the exact sum stated to have been expended—namely, £8 14s. 3d. The analysis is retained by the cashier, who, instead of entering £8 14s. 3d. as a payment, copies from the analysis into the cash book the several sums that go to make up the amount of the cheque, and from the cash book these items would eventually be posted to the ledger. The petty cashier, having cashed the cheque for £8 14s. 3d., adds the proceeds to the money in the cash-box. If no payments have been made in the meantime, it will be found that the cash in hand has now been restored to its original amount of £10.

At the end of January there should have been £1 5s. 9d. in the cash-box (£10, less £8 14s. 3d.), therefore an addition of £8 14s. 3d. thereto would replace the petty cashier at the beginning of February in the position he occupied on January 1st, of a debtor to his employers for the sum of £10 advanced for petty cash.

From the new fund thus formed he continues to make payments until the time comes to approach his chief for more money, when the same routine is observed as before.

As a consequence of the method now explained, the registration in the petty cash book of cheques received by the petty cashier is rendered unnecessary. There is no difficulty in testing the cash balance, because this must always coincide with the difference between the recorded current expenditure and the floating debt of £10. Thus, if up to February 15th the petty cashier has expended, according to his cash book, £5 9s. 2d. he ought to have £4 10s. 10d. in hand.

Advantages of the Imprest System. The advantages of this method from the administrative point of view are that it establishes a salutary control over the petty cash expenditure, and that it ensures, if faithfully carried out, the lodgment intact of all sums from outside sources which have been registered in the cash book. In the latter respect the system is similar to that recommended on page 536, but the petty cash book differs from that shown on page 276 in that the analysis figures are not posted to the ledger direct, but through the cash book, whereas the columnar totals of our tabular petty cash book are posted direct.

There is, however, nothing to prevent the petty cashier, with his chief's permission, making the periodic analysis in the petty cash book itself, thus enabling the ledger keeper to use it as a book of original entry from which the ledger postings could be made. If this were done, the cashier would merely enter in the cash book the amounts of the petty cash cheques, against which references to the petty cash book would be inserted in the folio column. The inquirer, on turning to the places in the petty cash book which had been pointed out in the cash book, would find that the amounts entered in total in the latter had been dealt with in detail in the former. But the initial £10 would be posted to the ledger direct.

The petty cashier might go even further than this by approximating the form of his cash register to that of the tabular petty cash book through the addition of analysis columns. By this means the labour of the monthly dissections of expenditure would be reduced and simplified.

Another Method. We may notice an alternative method to the imprest system of managing petty cash transactions, where moneys from outside sources are banked punctually, and without any deduction. This consists in keeping a separate petty or office cash book ruled with debit and credit columns, wherein all receipts of money from the bank and all payments except those made by cheque are duly recorded. There is no floating balance in this case, but amounts of £5 are drawn from the bank as often as they are wanted, and added to the cash balance. Except that in many cases there are no analysis columns in the petty cash book, this system is identical with that which now falls to be described.

A careful comparison of the various modes of handling and recording cash and petty cash should lead us to give our verdict in favour of the analysis or tabular petty cash book already mentioned. The highest, because the simplest, form of petty cash book which has come

within our knowledge is the one shown on page 276. To it, and also to the bank cash book on page 536, the student is now asked to refer.

The Tabular Petty Cash Book. In pursuance of the policy of having every account in the ledger, an account for petty cash has been opened on folio 25 of Messrs. Bevan & Kirk's general ledger. The first item on the debit side is the balance of 10s. as at September 1st, 1905 [see page 274], and the amounts drawn from bank during the month, as ascertained from the bank cash book [see page 536], follow in chronological order. The result should be a total debit of £90 10s., corresponding with the total of the "received" column in the petty cash book. On the credit side, the total expenditure for the month, as ascertained from the petty cash book, has been posted in one sum—namely, £89 13s. 11d. The account has been balanced off, and the balance of 16s. 1d., which agrees with that shown in the petty cash book, brought down to the October account.

The petty cash account in the ledger is nothing more than an epitome of the petty cash book, and might be dispensed with but that it affords a check upon the amounts shown in the "received" column of the petty cash book, and is useful for other reasons. Bearing in mind what was said as to the bank balance and the cash in hand constituting two portions of one fund, we see clearly why the transfer of money from bank to petty cash has the effect of debiting petty cash account and crediting bank account.

Treatment of Payments from Petty Cash. With regard to payments from petty cash, we notice that these, after being entered in the "paid" column, have been analysed under various heads. It should be pointed out that unanimity among business men in the matter of the particular accounts to which items of expense should be apportioned cannot be expected, and does not exist. But there are some rules which are of general application, and should be adhered to.

An example of what is meant occurs in Messrs. Bevan & Kirk's petty cash book. Under date of Sept. 27th, we have the item "Advertisement for salesman, 3s." It would be wrong, but the mistake is often made, to treat an item of this kind as a debit to Advertising account, because that account is opened for the specific purpose of showing the expenditure incurred in making known the firm's business to the utmost possible extent. What bearing has the advertising for a salesman or clerk upon the increase of business expected to flow from a well-ordered advertising campaign?

The Ledger Postings. We shall number the money columns to the right of the "paid" column in the petty cash book 1, 2, 3, 4, 5, 6 respectively. It having been shown that the cross-casting of the totals of all these columns is equivalent to the total amount expended, nothing now remains except to note the ledger postings. Jones & Co., Wm. Smith, and the Berlin Manufacturing Company are manufacturers for whom Bevan & Kirk act as agents. Out-of-pocket expenses paid from petty cash, and chargeable to all or any of them, are shown in columns 1, 2, 3, and pains must be taken to see that items are placed in the right columns. The special vice of the columnar system of bookkeeping is the risk of items getting into the *wrong* columns. The references at the foot of columns 1, 2, and 3 inform us that 7s. 2d. has been posted to the debit of Jones & Co.'s account in the general ledger (G.L. 51), 10s. 2d. has gone to the debit of Smith's account (G.L. 53), and 3s. 4d. to the debit of Berlin Manufacturing Company's account on G.L. 55.

The total of column No. 4 has been posted to the debit of Trade Expenses account, and we shall not be slow to admit the utility of the tabular method when we reflect that if all the items had been posted singly they would probably have occupied from forty to fifty lines in the ledger, while, if the petty cash had been summarised, the grouping of all the items would yet have proved a troublesome task.

Postage Column. Column No. 5 is reserved for stamps. By this means a check upon the postboy is established. The monthly total of the postages column appears as a debit on Postages account (G.L. 29).

The last column is headed "Sundries," and contains all the items which do not belong to any of the other columns. These are posed in detail, and therefore a special folio column is provided to admit of the insertion of ledger references.

We may refer to Transaction (*b*) for the sake of completing our remarks on Bevan & Kirk's postage book. "Sept. 20, stamps purchased, 5s." The postage book kept by Bevan & Kirk's junior clerk is a miniature of the firm's petty cash book, and the rules laid down for the latter will apply equally as well to the former. The Postage account in the general ledger already stands debited with £2, and, assuming the stock of stamps to have run out on Aug. 31st, this amount would represent the total debit for September, corresponding with the total of the "received" column in the postage book. On the credit side, post the total expenditure for the month as ascertained from the postage book, say £1 19s., balance the account, and bring down the balance of 1s., which should agree with that shown in the postage book brought down to the October account.

"Received" Column of Postage Book. The entries in the "received" column of the postage book represent transfers from petty cash to postages, and may be checked at any time by comparison with the Postage column in the petty cash book. Such transfers have the effect of crediting Petty Cash account and debiting Stamps or Postages account. The "paid" column of the postage book is analysed under the headings Jones & Co., Wm. Smith, Berlin Manufacturing Company, Office, Sundries. The procedure as to cross-casting the monthly totals and posting them to their respective accounts in the ledger is the same as that described for Bevan & Kirk's petty cash book.

A. J. WINDUS

Vocalization of *PL* and *PR*. The *pl* and *pr* series may sometimes be used to obtain a good outline, even though an accented vowel comes between the two consonants. In such a case the dot vowel BETWEEN the two letters is expressed by a small circle after the consonant stroke; thus

chairman, careless, cashiered, souvenir.

. A stroke vowel or diphthong is struck THROUGH the consonant; thus

school, record, tincture.

Single stroke words vocalized in the above ways are halved for either *t* or *d*; thus

court, cold.

When an initial hook or circle would interfere with a first-place vowel or diphthong, or a final hook or circle with a third-place vowel, the vowel-sign may be written at the BEGINNING or END of the consonant; as

child, dormouse, figuration.

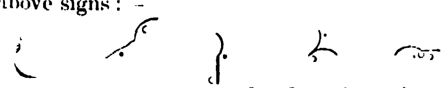
It is seldom necessary to vocalize the *pl* and *pr* series to mark an unaccented vowel; thus

permit, vocal.

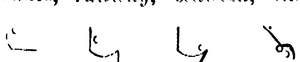
***W* and *Y* Diphthongs.** When *w* or *y* is followed by any simple vowel, long or short, and a diphthong is formed, it is represented by a semicircle written in the same position as the simple vowel; thus

		wah	*waw*	*yah*	*yaw*
eh	*oh*	*weh*	*woh*	*yeh*	*yoh*
ee	*oo*	*wee*	*woo*	*yee*	*you*

The following are examples of the use of the above signs:—



zouave, railway, seaweed, chamois, misquote,

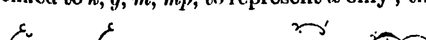


thwack, twenty, twinge, password, lamb's-wool.

The right semicircle ᐳ representing *waw* or *wŏ* may be prefixed to a stroke consonant where it is convenient; thus

walk, water, watcher, washer, war, warp.

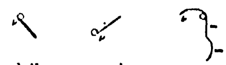
The left semicircle ᐸ is prefixed to downward *l*, to represent *wĭ*, and the right semicircle ᐳ is prefixed to *k*, *g*, *m*, *mp*, to represent *w* only; thus



William, Wilson, wake, wig, woman, wampum.

Diphonic or Two-Vowel Signs. The angular sign is employed for the representation of two consecutive vowels as follows:—

(*a*) Written in the first vowel-place to represent the vowel *ah* and any vowel immediately following *ah*: thus

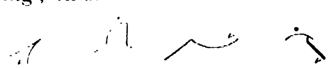


sahib, serai, maestoso.

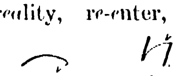
(*b*) Written in the second vowel-place to represent *ā* and any vowel immediately following; thus

layer, laity, betrayal.

(*c*) Written in the third vowel-place to represent the vowel *ē* or *ĭ* and any vowel immediately following; thus



real, reality, re-enter, amiable,



meander, geology.

The angular sign is employed for the representation of two consecutive vowels as follows:

(*a*) Written in the first vowel-place to represent the vowel *aw* and any vowel immediately following; thus

flawy, drawer, withdrawal.

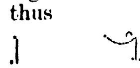
(*b*) Written in the second vowel-place to represent the vowel *ō* and any vowel immediately following; thus

poet, poetical.

(*c*) Written in the third vowel-place to represent the vowel *ōō* and any vowel immediately following; thus

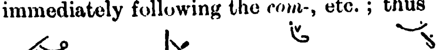
bruin, brewery, Louisa.

Prefixes. The syllable *com-* or *con-* occurring at the beginning of a word is expressed by a light dot written before the first consonant; thus



commit, community.

Medial *com-*, *con-*, or *cog-*, either in a word or phrase, is indicated by disjoining the form immediately following the *com-*, etc.; thus



recognise, decompose, confined, incumbent.

Accom- is represented by a disjoined or joined *k*; thus

accommodation, *accommodate.*

Inter-, *intro-*, or *enter-* is generally expressed by *nt*; thus

inter*lock*, intro*spect*, enter*prise*.

Magna-, *magne-*, or *magni-* is expressed by a disjoined ; thus

magna*nimity*, magne*tized*, magni*fy*.

Self- is represented by a disjoined circle *s*; thus

self-*defence*.

In- before the circled letters is expressed by a small hook, written in the same direction as the circle; thus

in*spiration*, in*strument*, in*scribe*, in*herent*.

Suffixes. The suffix *-ing* is expressed by the stroke , and *-ings* by ; thus

facing, *facings*, *evening*, *robbing*.

When the stroke is not convenient, *-ing* is expressed by a light dot at the end of the word, and *-ings* by a light dash; thus

hoping, *plotting*, *plottings*, *turning*, *turnings*.

The suffixes *-ality*, *-ility*, *-arity*, etc., are expressed by disjoining the preceding stroke; thus

formality, *carnality*, *geniality*.

The sign is employed as a contraction for *-ment*, when following *n*, *ns*, or a hook;

imprisonment, *commencement*.

The suffix *-mental*, or *-mentally* is expressed by *mnt*; thus

*instru*mental or *instru*mentality.

Where it is inconvenient to join the for *-ly*, it may be disjoined; thus

*friend*ly.

The circle *s* is used to express *-self* and the large circle to denote *-selves*; thus

*my*self, *him*self, *them*selves.

To express *-ship* is used, joined or disjoined, as in

*friend*ship, *steward*ship.

A disjoined is used to express *-fulness*; thus

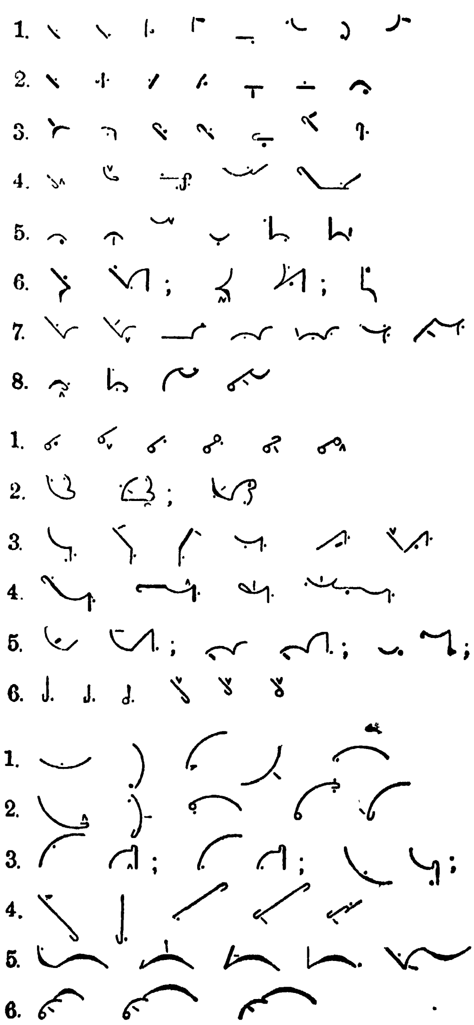
restfulness.

A disjoined is used for *-lessness* or *-lousness*; thus

*law*lessness, *sedulousness.*

Writing and Reading Practice. At this stage of his study, the student is advised to exercise his shorthand attainments by making use of suitable matter for writing and reading practice. He will find ample material in *Pitman's Journal* published weekly, price 1d.

Key to Exercises in Last Lesson



Fractions — continued. **Division. Brackets. Expression of Decimals as Vulgar Fractions. Fractions of Concrete Quantities.**

FRACTIONS

83. Division of Fractions. (i.) When the divisor is a whole number.

Suppose we have to divide $\frac{7}{9}$ by 4.

We know $\frac{7}{9} = \frac{28}{36}$. This fraction means that the unit is divided into 36 equal parts, and 28 of the parts taken. If we divide the 28 parts by 4, we get 7 of them—*i.e.* $\frac{7}{36}$. Hence $\frac{7}{9} \div 4 = \frac{7}{36}$.

Therefore, *to divide a fraction by a whole number, we multiply the denominator by that number.*

In the same way as already explained for multiplication, we cancel any common factors contained in the divisor and the numerator. Hence, if the numerator be exactly divisible by the divisor, we may *divide a fraction by a whole number by dividing the numerator by that number.*

Example 1. $\frac{27}{31} \div 18 = \frac{\cancel{27}^{\,3}}{31 \times \cancel{18}_{\,2}} =$ *Ans.*

Example 2. $\frac{36}{41} \div 9 = \frac{4}{41}$ *Ans.*

(ii.) When the divisor is a fraction.

In the operation $24 \div 3$, we have to find the number which, when multiplied by 3, will give 24. Similarly, to find the value of $\frac{3}{7} \div \frac{5}{9}$ we have to find the fraction which, when multiplied by $\frac{5}{9}$, will give $\frac{3}{7}$.

But $\frac{3 \times 9}{7 \times 5}$ is the fraction which gives $\frac{3}{7}$ when multiplied by $\frac{5}{9}$. Therefore, $\frac{3}{7} \div \frac{5}{9} = \frac{3 \times 9}{7 \times 5}$.

Hence, *to divide by a fraction, invert the divisor and multiply.*

As in multiplication, mixed numbers must first be reduced to improper fractions.

Example 3. Divide $3\frac{1}{14}$ by $5\frac{5}{42}$.

$$3\tfrac{1}{14} \div 5\tfrac{5}{42} = \frac{43}{14} \div \frac{215}{42} = \frac{\cancel{43}}{\cancel{14}} \times \frac{\cancel{42}^{\,3}}{\cancel{215}_{\,5}} = \frac{3}{5} \text{ Ans.}$$

84. Brackets. Brackets are symbols used to join together two or more quantities, to indicate that they are to be treated as a single quantity.

Thus, $(3\frac{1}{2} - 1\frac{1}{8}) \div 2\frac{3}{4}$ means that $1\frac{1}{8}$ is to be subtracted from $3\frac{1}{2}$, and the result divided by $2\frac{3}{4}$. The value of this expression is, therefore,

$$2\tfrac{3}{8} \div 2\tfrac{3}{4} = \tfrac{19}{8} \times \tfrac{4}{11} = \tfrac{19}{22}.$$

Without the brackets, the value would be

$$3\tfrac{1}{2} - \tfrac{9}{8} \div \tfrac{11}{4} = 3\tfrac{1}{2} - \tfrac{9}{8} \times \tfrac{4}{11} = 3\tfrac{1}{2} - \tfrac{9}{22} = 3\tfrac{1}{11}.$$

It is necessary to have several shapes for brackets, such as ( ), { }, [ ], since parts of an expression we wish to treat as a single quantity may already be enclosed in brackets.

Example. Find the value of

$$\left[\left\{(\tfrac{1}{2} + \tfrac{1}{3}) \div (\tfrac{1}{4} + \tfrac{1}{5})\right\} - 1\tfrac{4}{9}\right] \div (1\tfrac{1}{9} - \tfrac{19}{27}).$$

Given expression

$$= \left[\left\{\frac{5}{6} \div \frac{9}{20}\right\} - 1\tfrac{4}{9}\right] \div \frac{30 - 19}{27},$$

$$= \left[\left\{\frac{5}{\cancel{6}_{\,3}} \times \frac{\cancel{20}^{\,10}}{9}\right\} - 1\tfrac{4}{9}\right] \div \frac{11}{27},$$

$$= [1\tfrac{23}{27} - 1\tfrac{4}{9}] \div \frac{11}{27},$$

$$= \frac{23 - 12}{27} \div \frac{11}{27},$$

$$= \tfrac{11}{27} \times \tfrac{27}{11} = 1 \text{ Ans.}$$

Note that we first simplify the expressions in the innermost brackets, then proceed to the next inner bracket, and so on.

85. We have, so far, only considered fractions in which both the numerator and the denominator are integers. These are called *Simple Fractions.*

A *Complex Fraction* is one in which the numerator or denominator, or both, are fractions.

Thus $\frac{3\frac{1}{4}}{2\frac{3}{8}}$, $\frac{1}{\frac{5}{8} \times \frac{3}{4}}$, $\frac{1\frac{5}{7}}{8}$, are complex fractions.

Now, to divide a unit into 5 equal parts and take 3 of them gives the same result as dividing 3 units into 5 parts and taking one of them—*i.e.*, $\frac{3}{5}$ represents the quotient of 3 divided by 5.

Hence $\frac{\frac{5}{16}}{\frac{15}{24}}$ means $\frac{5}{16} \div \frac{15}{24}$.

Therefore, to simplify a complex fraction reduce both numerator and denominator to simple fractions, and divide the one by the other.

Example 1. Simplify $\dfrac{2\frac{1}{4} - 1\frac{5}{6} + 3\frac{3}{8}}{1\frac{1}{2} \div \frac{6}{13}}$.

Given expression

$$= \frac{4 + \frac{6 - 20 + 9}{24}}{\frac{3}{2} \times \frac{13}{\cancel{6}_{\,2}}} = \frac{3 + \frac{39 - 20}{24}}{\frac{13}{4}}$$

$$= 3\tfrac{19}{24} \div \frac{13}{4} = \frac{\cancel{91}^{\,7}}{\cancel{24}_{\,6}} \times \frac{\cancel{4}}{\cancel{13}} = \frac{7}{6} = 1\tfrac{1}{6} \text{ Ans.}$$

Example 2. Find the value of

$$\frac{\frac{1}{3}+\frac{1}{4}+\frac{1}{5}}{\frac{1}{2\frac{1}{3}}+\frac{1}{3\frac{1}{4}}+\frac{1}{4\frac{1}{5}}}.$$

Given expression

$$=\frac{\frac{20+15+12}{60}}{\frac{1}{\frac{7}{3}}+\frac{1}{\frac{13}{4}}+\frac{1}{\frac{21}{5}}}=\frac{\frac{47}{60}}{\frac{3}{7}+\frac{4}{13}+\frac{5}{21}}$$

$$=\frac{\frac{47}{60}}{\frac{117+84+65}{273}}$$

$$=\frac{47}{60}\div\frac{266}{273}=\frac{47}{\cancel{60}_{20}}\times\frac{\cancel{\cancel{273}}^{\cancel{91}\,13}}{\cancel{266}_{38}}=\frac{611}{760}\ \textit{Ans.}$$

86. A *Compound Fraction* is a fraction of a fraction.

Thus, $\frac{3}{5}$ of $\frac{4}{7}$ is a compound fraction.

To obtain $\frac{3}{5}$ of $\frac{4}{7}$ we have to divide $\frac{4}{7}$ into 5 equal parts and take 3 of them. But $\frac{4}{7} \div 5 = \frac{4}{35}$. And three of these parts $= 3 \times \frac{4}{35} = \frac{12}{35}$.

Hence $\frac{3}{5}$ of $\frac{4}{7} = \frac{12}{35}$; which is also the value of $\frac{3}{5} \times \frac{4}{7}$.

Therefore, the word "of" has the same meaning as $\times$.

87. *In expressions where additions and subtractions as well as multiplications and divisions occur, the multiplications and divisions must be performed before the additions and subtractions.*

Thus $\frac{3}{4} \div \frac{7}{8} + \frac{3}{8}$ means that $\frac{3}{4}$ is to be divided by $\frac{7}{8}$, and $\frac{3}{8}$ is to be added to the result.

It does not mean that $\frac{3}{4}$ is to be divided by the result obtained when we add $\frac{3}{8}$ to $\frac{7}{8}$. This would be represented by $\frac{3}{4} \div (\frac{7}{8} + \frac{3}{8})$.

In such expressions as $\frac{1}{4} \div \frac{3}{8} \times \frac{5}{9}$, each of the symbols $\times$, $\div$, refers only to the fraction immediately following it.

Thus $\quad \frac{1}{4} \div \frac{3}{8} \times \frac{5}{9} = \frac{1}{4} \times \frac{8}{3} \times \frac{5}{9} = \frac{10}{27}.$

But, if the above expression were written $\frac{1}{4} \div \frac{3}{8}$ of $\frac{5}{9}$ it would mean that $\frac{3}{8}$ of $\frac{5}{9}$ is to be treated as a single quantity, and the value would be $\frac{1}{4} \div (\frac{3}{8} \times \frac{5}{9}) = \frac{1}{4} \div \frac{15}{72} = \frac{1}{4} \times \frac{72}{15} = \frac{6}{5} = 1\frac{1}{5}$.

88. Continued Fractions. A fraction of the following form is called a *Continued Fraction.*

$$\cfrac{1}{2+\cfrac{1}{5+\cfrac{1}{3+\cfrac{2}{1+\frac{5}{6}}}}}$$

To simplify it, we begin at the lowest line. Thus, the given fraction

$$=\cfrac{1}{2+\cfrac{1}{5+\cfrac{1}{3+\cfrac{2}{\frac{11}{6}}}}}=\cfrac{1}{2+\cfrac{1}{5+\cfrac{1}{3+\frac{12}{11}}}}$$

$$=\cfrac{1}{2+\cfrac{1}{5+\frac{11}{45}}}=\cfrac{1}{2+\frac{45}{236}}$$

$$=\frac{236}{517}\ \textit{Ans.}$$

EXAMPLES 10

Arrange in order of magnitude, writing the least first:

1. $\frac{8}{21}$, $\frac{13}{35}$, $\frac{11}{28}$.
2. $\frac{81}{95}$, $\frac{46}{57}$, $\frac{97}{114}$, $\frac{31}{38}$.
3. $\frac{23}{222}$, $\frac{31}{322}$, $\frac{41}{399}$.

Find the value of

4. $3\frac{4}{7} + 1\frac{3}{5} + \frac{13}{21} + 5\frac{4}{15}$.
5. $\frac{13}{30} + 4\frac{5}{42} - 2\frac{7}{90}$.
6. $3\frac{2}{3} - 4\frac{3}{4} + 5\frac{1}{5} - 6\frac{5}{6} + 7\frac{6}{7}$.
7. $\frac{117}{113} - \frac{13}{299} + \frac{57}{253}$.
8. $\frac{1}{8}$ of $\frac{3}{14}$ of $5 - \frac{4}{7}$ of $\frac{2}{9}$ of $\frac{3}{4}$.
9. $(2\frac{1}{2}$ of $4\frac{3}{4} - 3\frac{5}{12}) \div (\frac{5}{9} + \frac{4}{5}$ of $3\frac{1}{3})$.
10. $6\frac{7}{8} \times 3\frac{9}{11} - 7\frac{1}{16} \div 5\frac{11}{13} - 4\frac{1}{2} \times 5\frac{5}{16}$.
11. $\left\{\frac{2}{7} + (5\frac{1}{2} + 3\frac{1}{8}) \text{ of } \frac{19}{23}\right\} \div \left\{8\frac{5}{7} - (4\frac{8}{9} \div \frac{5}{9} \text{ of } 5\frac{1}{2})\right\}$.
12. $\dfrac{2\frac{1}{2} + 3\frac{5}{6}}{5\frac{1}{5} - 4\frac{1}{4}} \times \dfrac{12\frac{2}{7} \text{ of } 13\frac{7}{8}}{9\frac{1}{4} \text{ of } 6} \div \dfrac{(7\frac{1}{2} - \frac{3}{4} \text{ of } \frac{8}{9}) \div 8\frac{1}{5}}{(10\frac{5}{8} - 2\frac{3}{8} \text{ of } 4) \div 3\frac{2}{7} \text{ of } 7\frac{1}{2}}$.
13. $\cfrac{10}{3-\cfrac{1}{1-\cfrac{2}{3+\frac{5}{7}}}}$
14. $\cfrac{1}{3+\cfrac{1}{2+\cfrac{1}{5+\frac{1}{4}}}} \times \cfrac{1}{1+\cfrac{1}{3+\cfrac{1}{3+\frac{1}{5}}}}$
15. $3\frac{1}{3} - \cfrac{1}{2-\cfrac{1}{3-\cfrac{1}{2-\cfrac{1}{1-\cfrac{1}{3+\frac{1}{3}}}}}}$

89. Expression of Decimal Fractions as Vulgar Fractions.

Example. Express 5·375 as a vulgar fraction.

·375 = 375 thousandths.

Therefore, $5{\cdot}375 = 5\frac{375}{1000} = 5\frac{3}{8}$ *Ans.*

Hence, the rule is: Take the digits of the decimal for numerator; for the denominator

put down 1 followed by as many noughts as there are digits in the decimal. Reduce this fraction to its lowest terms.

90. Expression of Vulgar Fractions as Decimals.

We have seen [Art. **85**] that a vulgar fraction represents the quotient of the numerator divided by the denominator. Therefore, to convert a vulgar fraction to a decimal fraction, we divide the numerator by the denominator.

The process is, in fact, the same as that already explained in Art. **33**.

Example. Express $\frac{3}{32}$ as a decimal.

4)3·0   Use factors of 32, and proceed
8) ·75   as in Ex. **1**, Art. **33**.
·09375 *Ans.*

It will be found in many cases that there is always a remainder, so that the quotient can be continued indefinitely. [Ex. **2**, Art. **33**.]

FRACTIONS OF CONCRETE QUANTITIES

91. From the definition of a vulgar fraction, it is clear that to obtain any required fraction of a given compound quantity we divide by the denominator of the fraction and multiply the result by the numerator.

Example **1.** Find the value of $\frac{7}{9}$ of £3 17s. $4\frac{1}{2}$d.

£	s.	d.
9)3	17	$4\frac{1}{2}$
	8	$7\frac{1}{6}$ *
		7
£3	0	$2\frac{1}{6}$ *Ans.*

* After dividing the pence by 9, there is a remainder $1\frac{1}{2}$d. $= \frac{3}{2}$d. and $\frac{3}{2} \div 9 = \frac{3}{18} = \frac{1}{6}$.

Example **2.** Find the value of $4\frac{3}{8}$ of £6 18s 2d.

£	s	d.	
8) 6	18	2	
	17	$3\frac{1}{4}$	$= \frac{1}{8}$ of £6 18s. 2d.
		3	
2	11	$9\frac{3}{4}$	$= \frac{3}{8}$ of £6 18s. 2d.
27	12	8	$= 4 \times$ £6 18s. 2d.
£30	4	$5\frac{3}{4}$ *Ans.*	

To obtain the value of a given *decimal* fraction of a concrete quantity, we may reduce the decimal to a vulgar fraction and proceed as above.

Or, we may adopt the method shown in the following examples.

Example **3.** Find the value of 2·13625 of £5.

2·13625 of £5 = £10·68125
    20
13·62500 s.
    12
7·500 d.
    4
2·0 far.
£10 13s. $7\frac{1}{2}$d. *Ans.*

Explanation. Multiply 2·13625 by 5. Multiply *the decimal part* of the product by 20 to reduce it to shillings. Multiply the decimal part of the shillings by 12 to reduce it to pence and so on.

Example **4.** Find the value in lb. and decimal of a lb. of ·0123 of 3 tons 5 cwt. 47 lb.

3 tons 5 cwt. 47 lb.   Reduce the tons, etc., to lb. and take ·0123 of the result.
20
65 cwt.
112
607
672
7327 lb.
·0123
73·27
14·654
2·1981
90·1221 lb. *Ans.*

92. The converse of this operation is to find by what fraction (vulgar or decimal) we must multiply one given quantity to produce another given quantity.

Example **1.** What fraction of 2 tons 7 cwt. 2 qrs. is 1 ton 8 cwt. 2 qrs.?

Express each of the quantities as simple quantities in terms of the same unit.

Thus, 2 tons 7 cwt. 2 qrs. = 190 qrs.
and 1 ton 8 cwt. 2 qrs. = 114 qrs.

Hence 1 ton 8 cwt. 2 qrs. is evidently $\frac{114}{190}$ of 2 tons 7 cwt. 2 qrs.—

i.e., Required fraction $= \frac{114}{190} = \frac{3}{5}$ *Ans.*

We therefore have the following rule. To express one compound quantity as the fraction of another of the same kind, reduce the quantities to terms of the same unit; take the first quantity for numerator and the second for denominator.

Example **2.** Reduce £7 3s. $2\frac{3}{4}$d. to the decimal of £5 4s. 2d.

£ s. d.	£ s. d.	
7 3 $2\frac{3}{4}$	5 4 2	
20	20	Here we reduce the two amounts to farthings, and divide the first by the second.
143 s.	104 s.	
12	12	
1718 d.	1250 d.	
4	4	
6875 far.	5000 far.	

5·000)6·875
1·375 *Ans.*

93. Miscellaneous Questions Involving Fractions.

Example **1.** In a cricket match, one man made $\frac{1}{3}$ of the total runs; another man made $\frac{1}{3}$ of the remainder. These two scores differed by 7; what was the total?

First man made $\frac{1}{3}$ of the total.

Second man made $\frac{1}{3}$ of the remainder, $= \frac{1}{3}$ of $\frac{2}{3}$ of the total $= \frac{2}{9}$ of the total. Therefore, difference between their scores $= (\frac{1}{3} - \frac{2}{9})$ of the total $= \frac{3-2}{9} = \frac{1}{9}$ of the total.

Hence, 7 runs is $\frac{1}{9}$ of the total; so that the total $= 7 \times 9 = 63$ runs *Ans.*

Example 2. In paying two bills, one of which exceeds the other by $\frac{1}{3}$ of the less, the change out of a £5 note is half the difference of the bills. What are the two amounts ?

Difference between the bills $= \frac{1}{3}$ of smaller bill.

And, change out of £5 $= \frac{1}{2}$ difference between the bills $= \frac{1}{2}$ of $\frac{1}{3}$ of smaller $= \frac{1}{6}$ of smaller.

But, the larger bill equals $1\frac{1}{3}$ times the smaller. Therefore, since the two bills and the change make £5, we have

$(1\frac{1}{3} + 1 + \frac{1}{6})$ of the smaller bill = £5;

i.e., $2\frac{1}{2}$ times the smaller = £5.

Therefore,

$$\left.\begin{array}{l}\text{Smaller bill} = \dfrac{£5}{2\frac{1}{2}} = \dfrac{£5 \times 2}{5} = £2 \\ \text{and} \\ \text{Larger bill} = £2 + \frac{1}{3} \text{ of } £2 = £2\ 13s.\ 4d.\end{array}\right\} \underline{\textit{Ans.}}$$

Example 3. For one-third of a mile a submarine cable is laid overland, $\frac{1}{12}$ of it is suspended in the water, $\frac{73}{80}$ lies on the bed of the sea. Find its length.

The fraction of the cable laid overland is evidently $(1 - \frac{1}{12} - \frac{73}{80})$ of its length.

$$= \frac{240 - 20 - 219}{240} = \frac{1}{240} \text{ of its length.}$$

$\therefore$ $\frac{1}{240}$ of its length $= \frac{1}{3}$ of a mile.

Hence, total length $= \frac{240}{3} =$ 80 miles *Ans.*

EXAMPLES 11

1. Reduce the difference between $\frac{1}{7}$ of $\frac{5}{12}$ of a guinea and $\cdot128$ of £1 to the decimal of half-a-crown.

2. Express $\dfrac{2\cdot5}{\cdot375} \times \dfrac{4\cdot55}{3\frac{1}{4}}$ of an hour in minutes.

3. A sum of money is divided amongst three men, so that the first has $\frac{1}{4}$ of it, the second has $\frac{2}{9}$ and the third has 38s. What is the sum ?

4. A boy sold his knife for half-a-crown and gained a quarter of what it cost him. For how much should he have sold it to gain a quarter of the selling price ?

5. A man left £450 to his youngest son, $\frac{3}{8}$ of his money to his second son, and to his eldest son he left as much as to the other two together. How much money did he leave altogether ?

6. Three brothers have a sum of money divided amongst them so that each has $\frac{5}{8}$ of what his next eldest brother has. The eldest has £73 2s. 6d. more than the youngest. Find the sum of money.

7. What decimal of $\frac{3}{7}$ of $2\frac{11}{12}$ of £2 is equal to $\cdot65375$ of £17 $-$ $14\cdot295$ crowns ?

8. In walking from one town to another, a man finds that at two o'clock he has completed $\frac{1}{4}$ of his journey, and at 2.15 he has completed $\frac{1}{3}$. At what time will he reach his destination ?

9. A woman had a certain number of oranges. She sells A half of them and one more, to B she sells half the remainder and one more, to C she sells half the new remainder and one more, and she now sells one more than half of what she has left to D. She has three oranges left. How many had she at first ?

10. At a point of his journey from one place to another, a man noticed that $\frac{4}{5}$ of the distance he had already travelled was $\frac{1}{2}$ the distance he still had to go. After another $2\frac{1}{4}$ miles he had just completed half his journey. How many miles had he still to go when he made the first observation ?

11. A cask is filled with a mixture consisting of 4 parts of spirits to 3 parts of water. When $3\frac{1}{2}$ gallons have been drawn off, and the cask filled up with water, the mixture then consists of 3 parts spirits and 4 parts water. How much does the cask hold ?

Answers to Examples 10

1. $\frac{13}{35}$, $\frac{8}{21}$, $\frac{11}{28}$. **2.** $\frac{49}{57}$, $\frac{31}{38}$, $\frac{97}{114}$, $\frac{81}{95}$. **3.** $\frac{31}{322}$, $\frac{41}{399}$, $\frac{23}{222}$. **4.** $11\frac{2}{35}$. **5.** $1\frac{121}{252}$. **6.** $5\frac{71}{120}$. **7.** 1. **8.** $\frac{13}{336}$. **9.** $2\frac{5}{8}$. **10.** 1. **11.** $1\frac{1}{24}$. **12.** 1. **13.** 12. **14.** $\frac{2}{9}$. **15.** $2\frac{1}{2}$.

Answers to Examples 11

1. $\cdot524$. **2.** 560 min. **3.** Share of third $= (1 - \frac{1}{4} - \frac{2}{9})$ of whole $= \frac{19}{36}$ of whole. $\therefore$ $\frac{1}{36}$ of sum = 2s., *i.e.*, sum = 72s. = £3 12s. **4.** Half-a-crown $= \frac{5}{4}$ of the cost. $\therefore$ Knife cost $\frac{4}{5}$ of 2s. 6d. = 2s. Hence, if the boy sells it to gain $\frac{1}{4}$ of the selling price, this 2s. will be the remaining $\frac{3}{4}$ of the selling price. Hence he must sell it for $\frac{4}{3}$ of 2s. = 2s. 8d. **5.** Since the eldest had as much as the other two together he must have had half the entire sum. The second son had $\frac{3}{8}$. $\therefore$ Youngest had $1 - \frac{1}{2} - \frac{3}{8} = \frac{1}{8}$ of the sum. $\therefore$ Sum the father left $= 8 \times £450 =$ £3600. **6.** Second has $\frac{5}{8}$ eldest; youngest has $\frac{5}{8}$ of this, *i.e.*, $\frac{25}{64}$ of the eldest. $\therefore$ The eldest has a sum equal to $1 - \frac{25}{64} = \frac{39}{64}$ of his own share more than the youngest. $\therefore$ Eldest's share $= \frac{64}{39}$ of £73 2s. 6d. = £120. The second has $\frac{5}{8}$ of £120 = £75. The third has $\frac{5}{8}$ of £75 = £46 17s. 6d. $\therefore$ The total money = £120 + £75 + £46 17s. 6d. = £241 17s. 6d. **7.** $3\cdot016$. **8.** Between 2 and $2\cdot15$, *i.e.*, in $\frac{1}{4}$ hour he does $\frac{1}{3} - \frac{1}{4} = \frac{1}{12}$ of his journey. But at 2.15 he still has $\frac{2}{3}$ to do. This will take him $\frac{2}{3} + \frac{1}{12} = 8$ quarter hours. He thus finishes 2 hours after 2.15, *i.e.*, at 4.15. **9.** 3 oranges = 1 orange less than half the number she had before selling to D, *i.e.*, 4 was half the number she had. She therefore sold D 5 out of the 8 she had on leaving C. Similarly, she sold C 10 out of 18 she had on leaving B; she sold B 20 out of 38 she had on leaving A; and she sold A 40 out of 78 she had at first. Thus, required number = 78. **10.** $\frac{4}{5}$ of distance gone $= \frac{1}{2}$ distance left. $\therefore$ Distance gone $= \frac{1}{2} \times \frac{5}{4} = \frac{5}{8}$ of distance left. He must therefore have already gone $\frac{5}{13}$ of the whole distance. Now, $\frac{5}{13}$ is $(\frac{1}{2} - \frac{5}{13}) = \frac{3}{26}$ of the whole distance short of half-way. Hence, $2\frac{1}{4}$ miles $= \frac{3}{26}$ of the whole distance. $\therefore$ Whole distance $= \frac{26}{3} \times \frac{9}{4}$ miles $= 19\frac{1}{2}$ miles. $\therefore$ Reqd. answer $= \frac{8}{13}$ of $19\frac{1}{2}$ miles $= \frac{8}{13} \times \frac{39}{2} =$ 12 miles. **11.** At first, cask contains $\frac{4}{7}$ spirits: afterwards it contains $\frac{3}{7}$ spirits; hence $\frac{1}{7}$ of a cask of spirits was drawn off. And the 14 quarts drawn off contained $\frac{4}{7}$ of 14—i.e., 8 quarts of spirits; therefore $\frac{1}{7}$ of the cask is 8 quarts, and the whole cask is 56 quarts, or 14 gallons.

H. J. ALLPORT

A KEY TO THE HARMSWORTH SELF-EDUCATOR

From this table of the 25 groups of the Self-Educator the student may find the place of any subject treated in the work. The main groups appear in regular numerical order in each part of the Educator, each group continuing until complete. The sub-divisions of the groups appear as nearly as possible in the order of this page.

Group 1. Success

The Secrets of a Successful Life. Personality. Applied Education. Ideas. The Qualities that Win in the World.

Group 2. Geography and Travel

GEOGRAPHY. Physical, Political, and Commercial.
TRAVEL. Educational Travel. How to See the World.

Group 3. Arts and Crafts

ART. Ideals and History of Art. The Old Masters.
DRAWING. Freehand. Object. Brush. Memory. Light & Shade.
PAINTING. Theory and Training.
DESIGN. Design in Crafts and Trades. Book-decoration. Illumination. Design for textiles, wallpapers, metal work.
SCULPTURE. Modelling. Chiselling. Casting.
ARCHITECTURE. Theory. Styles. Training.
CARVING. Wood. Bone. Ivory. Tortoiseshell.
ART METAL WORK. A Practical Course.
PHOTOGRAPHY. A Course of Simple Lessons with a Camera.

Group 4. Physiology and Health

PHYSIOLOGY. Structure and Working of the Human Body.
HEALTH. The Laws of Health and Personal Hygiene.

Group 5. Agriculture and Gardening

FARMING. A Practical Course in the Cultivation of the Earth. Live-stock. Dairying. Poultry. Beekeeping.
FORESTRY. The Theory and Practice of Managing Trees.
GARDENING. Gardens for Pleasure and Profit.

Group 6. Chemistry

CHEMISTRY. Complete Course in Theory and Practice.
APPLIED CHEMISTRY. The Applications of Chemistry in Industry. Chemical Analysis. Acids and Alkalies. Oils and Fats. Waxes. Candles. Soap. Glycerine. Volatile Oils and Perfumes. Paints and Polishes. Glues. Starch. Inks. Coal Tar Products. Wood Distillation. Celluloid. Matches. Artificial Manures. Electro-chemistry. Water-Softening. Waste Products. Artificial Silk.

Group 7. History

The Story of All Ages and Peoples for Over Ten Thousand Years—From Egypt and Babylon to Europe in 1914.

Group 8. Civil Engineering and Transit

CIVIL ENGINEERING. Surveying. Varieties of Construction. Reinforced Concrete. Roads. Bridges. Railways and Tramways. Water Supply. Sewerage. Refuse. Hydraulics. Pumps. Harbours. Docks. Lighthouses.
VEHICLES. Construction and Use. Cycles. Cabs, Buses, Trams.
MOTORS. Design and Management of a Motor Car.
AVIATION. Science and Management of Flying Machines.
RAILWAYS. The Management and Control of Railways.
SHIPBUILDING. Shipping. Design and Construction.

Group 9. Literature and Journalism

LITERATURE. A Survey of English Literature and Foreign Classics. The World's Great Books and their Writers.
JOURNALISM. How to Become a Journalist. A Guide to Newspaper Life. How to Write. The Journalist's System.
PRINTING. Composing by Hand and Machine—Linotype and Monotype. Stereotyping and Printing.
TYPE. Type Cutting and Founding.
ENGRAVING AND ETCHING. Blockmaking and Process Work.
LITHOGRAPHY. Printing from the Stone.
BOOKBINDING AND PUBLISHING. Binding and Issuing Books.

Group 10. Civil Service and Professions

CIVIL SERVICE. The Three Branches of the Public Services of the British Empire—Municipal, National, Imperial.
BANKING. The Whole Practice of Banking.
LAW. How to Become a Solicitor or Barrister.
MEDICINE. Training of a Doctor. Veterinary Surgeons. Dentists. Chemists and Druggists. Nurses.
INSURANCE. Health. Unemployment. Life. Fire. Accident.
AUCTIONEERING AND VALUING. Practical Training.
ESTATE AGENCY. Management of a Great Estate.
CHURCH. How to Enter the Ministry of all Denominations.
SCHOLASTIC. Teachers. Professors. Governesses. Tutors.
SECRETARIES. Institution Officials. Political Agents. Lecturers.
LIBRARIES. Management of Libraries. Cataloguing.
ARMY, NAVY MERCHANT SERVICE. How to Enter Them.

Group 11. Life and Mind

BIOLOGY. The Rise of Life. Evolution. Heredity.
PSYCHOLOGY. The Mind of Man.
SOCIOLOGY. Social Conditions. Welfare of Communities.
EUGENICS. Human Betterment and the Future of the Race.

Group 12. Business

BUSINESS. The Management of a Successful Business. System. Simple Political Economy.
SHOPKEEPING. All Kinds of Shops and Small Trades.
ADVERTISING. The Value of Advertising. How to Advertise. How to Write Advertisements. How to Get Them.

Group 13. Physics and Power

PHYSICS. The Science of Matter and Motion.
POWER. Sources and Uses of Power. Air. Water. Wind. Sun. Steam. Oil. Gas. For Electricity, see Group 16.
PRIME MOVERS. Structure and Management of all Engines.

Group 14. Building Trades

BUILDING. The Building Trades and Building Materials: their Manufacture and Use. Building a House. Excavating. Drainage. Bricks, Limes, and Cements. Bricklaying. Clay Wares. Reinforced Concrete. Masonry. Carpentry. Slates and Tiles. Plumbing. Joinery. Foundry and Smith's Work. Painting. Papering and Glazing. Heating. Lighting. Ventilation. Quantity Surveying.
WOOD-WORKING MACHINERY. The Machines Used in Working Wood: Sawing, Turning, Planing, Moulding.
CABINET-MAKING and UPHOLSTERING.

Group 15. Natural History

BOTANY. Flowers. Plants. Seeds. Trees. Ferns. Mosses. Fungi.
ZOOLOGY. Mammals. Birds. Fishes. Reptiles. Insects. Lower Forms of Life.
BACTERIOLOGY. The Story of Microbes. Bacteriology in Relation to Health and Industry.

Group 16. Electricity

ELECTRICITY. Its Development and Countless Applications. Electrical Engineering.
TELEGRAPHS AND TELEPHONES. The Instruments and How to Operate Them.
WIRELESS TRANSMISSION. The Main Systems and their Methods of Working.

Group 17. Music

OLD NOTATION AND TONIC SOLFA. Tuition in All Instruments. Orchestration.
ELOCUTION AND SINGING. The Voice and its Treatment.
MUSICAL INSTRUMENTS. Their Design and Manufacture.

Group 18. Manufactures

TEXTILES. The Textile Trades from Beginning to End. Cotton. Wool. Silk. Hemp. Flax. Jute. Carpets.
LEATHER. The Leather Industry. Tanning. Boots and Shoes. Saddlery. Belting. Gloves. Sundry Leather Goods.
GLASS. Manufacture of All Kinds of Glass. Stained Glass.
EARTHENWARE. The Craft and Industry of Pottery.
PAPER. Papermaking of All Kinds.
RUBBER. The Source and Preparation of Rubber, and Manufacture of Rubber Goods.
TOBACCO. Cultivation and Manufacture. Tobacco Pipes.
FOOD SUPPLY. Milling. Breadmaking. Biscuits and Confectionery. Sugar. Condiments. Fruit. Fisheries Food Preservation.
BEVERAGES. Tea. Coffee. Chocolate. Cocoa. Brewing. Wines and Ciders. Mineral Waters.
BASKETMAKING. CORK. WATTLE. CANE. BARKS BRUSHES.

Group 19. Astronomy. Geology. Archæology

ASTRONOMY. The Universe as We Know It. Millions of Worlds. A Survey of the Solar System.
GEOLOGY. The Structure of the Earth. Petrology. Crystallography. Palæontology.
ARCHÆOLOGY. Buried History. The New Story of the Old World as Revealed by the Excavator.

Group 20. Mechanical Engineering

ENGINEERING. Applied Mechanics. Workshop Practice. Machine Tools. Machines and Appliances. Cranes.
DRAWING for Coppersmiths, Tinmen, and Boilermakers.

Group 21. Languages

LATIN. ENGLISH. FRENCH. GERMAN. SPANISH.

Group 22. Dress and Housekeeping

DRESS. Principles of Dressmaking. Underclothing, Tailoring. Millinery. Hatters. Furs and Feathers
HOUSEKEEPING. Domestic Management. Servants and their Duties. Cookery. Laundry.

Group 23. Metals and Minerals

METALS. Metallurgy. Properties and Characteristics of Metals. Iron and Steel. Copper. Tin. Zinc. Precious Metals.
METAL MANUFACTURES. Arms and Ammunition. Cutlery. Clocks and Watches. Jewellery. Scientific Instruments.
MINERALS. Mineralogy. Properties and Characteristics of Minerals.
MINING. Coal. Gold. Diamonds. Tin.
QUARRYING. The Appliances and Processes of Extracting and Preparing Stone.
GAS. The Process of Manufacture.
PETROLEUM. Extraction and Refining Processes.

Group 24. Clerkship

ACCOUNTANCY. Complete Training. Bookkeeping.
SHORTHAND. Pitman's System, with Latest Improvements
TYPEWRITING. Working and Management of All Machines

Group 25. Mathematics

Arithmetic. Algebra. Simple Graphs. Euclid. Trigonometry

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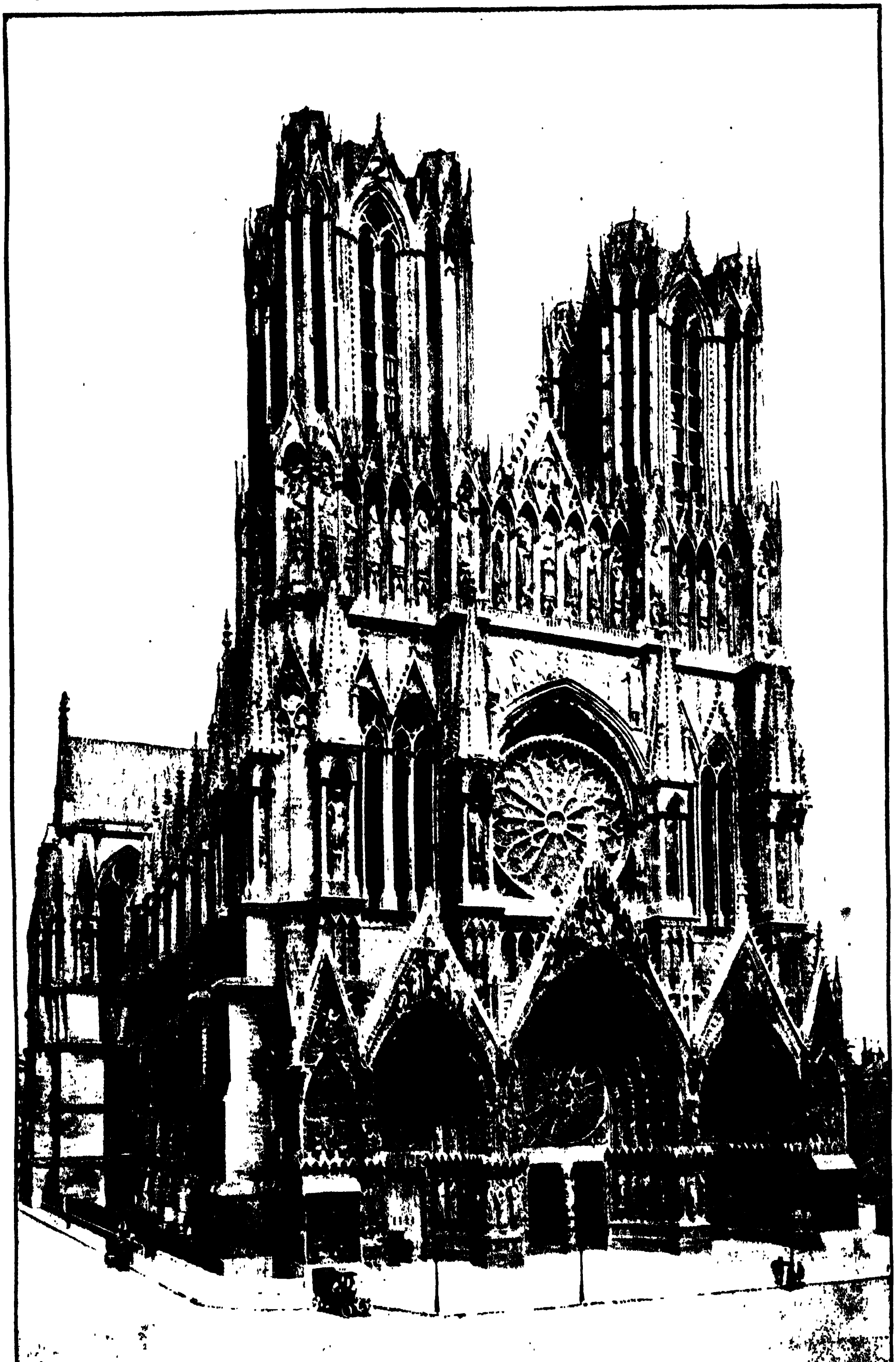
THE GLORIOUS CATHEDRAL OF RHEIMS



THE UNRIVALLED FRONT OF THE GOTHIC MASTERPIECE OF FRANCE

FACING PAGE 1077

The Shortness of Life. Its Present and Future.
The All-Round Man. Public Interests. The Home.

THE MANAGEMENT OF LIFE

THE brevity of human life is usually not realised by men until many of its best years have escaped them. A great danger to happiness in life lies in this fact. It is so difficult for a man, especially for a young man, to realise that life will never offer him hours more valuable than those which he is living in anticipation of a possible future. Indeed, the most valuable of the few years of a man's life are those that lie between childhood and his prime, and yet curiously these are apt to be regarded not so much as life itself, as years to be lived through in expectation of a better time to come. It is for this reason that a man will so often spend his best years in mere acquisition, in building, or, as is so often the case, in vain endeavour to build, a fortune to be enjoyed some day—some far-off day. If there is great success in this endeavour, and the fortune is built up, it is usually found valueless by its owner, who finds himself past the years in which it could bring him the enjoyment he hoped for. If there is failure, then the latter years of life may be embittered, not only by loss of youth and prime, but by loss of the false end and aim whose pursuit has wasted youth and prime. Thus it is that success in life regarded as fortune to be enjoyed at some distant future is nothing more or less than a mirage.

The first thing to grasp, then, as a condition of making a real success of life is to remember that life is here and now, and not upon a distant horizon—nay, that it is more here and now than it will probably ever be when, after long journeying, the horizon is reached, and another horizon, bleaker and unkinder, arises before the traveller. The horizon of the young man is formed by the everlasting hills; the horizon of the middle-aged man is a sheer descent. Good it is, therefore, most truly and undeniably, for youthful eyes to aspire, but let the youth remember that the climbing is Life itself, and that life is not postponed until the period when the hoped-for summit is at last reached. We have to count with the brevity of life in making our plans of life. Those who make the most of their lives are those who, remembering the short span of human existence, seek to live a full and varied and healthy and useful life in the present, and who, while not forgetting the future or failing to make provision for it, remember that each year that passes is for them a period which will not be lived again, and that each present year is something that is being consumed both for the first and the last time.

Life being here and now, the calling or profession of a man is most surely the greater part of his life. In the better ordered world of the future toward which we are slowly steering, joy in work will be universal, but in these, the early years of the twentieth century, joy in work is unfortunately the perquisite of a few. For the great majority work has to be accomplished under such conditions and upon such terms of remuneration that labour appears as a subtraction from life rather than a part of it. The machine-made employments and irksome routines, the purpose of which is infrequently perceived by those who perform them, rob many men of large parts of their lives by making work something not enjoyed but endured in order to obtain the means of living. The means of living *when*? In the few hours that are left when work is done, which alone count as "life." Under such circumstances life presents itself to the observer as fractions of days that are few. Under present conditions it is only the minority who attain the three score years and ten of the Psalmist, but even for the worker who attains advanced years, brief is the span of life when working hours are counted as something less than life. We have to endeavour to counter the conception that the life of the majority of men and women must necessarily be sharply divided between an irksome work-time and an idle playtime. We must have faith that it is possible to restore the whole of his life to the worker by giving him happiness in his work—by winning joy in work for every well-intentioned man.

It is misjudgment of the span and plan of life which so often leads to the postponement of marriage, and sometimes to its unhappy and indefinite postponement. Marriage is often relegated to some undated year at which success, as measured by income, shall have been won. Such postponement means the loss of the joy of early parenthood. It means also the loss of the tremendous happiness of watching a great part of the career of one's children, and even of one's children's children. The man of forty-five, with a son of twenty who has had the benefit of his wise guidance, has made at least one great success in life which he could never have won if he had postponed his marriage until he was thirty-five. It is true that the man marrying, at, say, thirty-five years of age may hope, when approaching sixty, to possess the happiness of an adult son, but he will be past his prime, and he will have lost not only a decade of parenthood, but much more than that.

Many young men are tempted to believe that marriage and parenthood are ties to development and hindrances to success. The fact is that the entertaining of such a conception of life by any young man is proof that he lacks at least some of the elements that make for success. The man too timid to marry is not likely to possess enough courage to confront other and more difficult adversaries than the support of a family. The present writer well remembers sitting at a public dinner with a man who has won extraordinary success in public life, who himself married early, and who in early middle age has several charming children. Looking across the banqueting tables, the great politician—a Cabinet Minister—saw a young and rising man who has already made a name in his profession. "I like that man," he said. "He had the courage to marry the girl he loved while he was poor." Was it not that same element of courage and of confidence which gave professional success?

We have spoken of the brevity of life. There are good signs, however, that man is learning how, within certain limits, to prolong his life. We have but to look at the obituary notices in "The Times" newspaper, at the beginning of the twentieth century, to see what a considerable proportion of the well-to-do classes die at an advanced age. It is now no uncommon thing for death to be postponed until after the eightieth year. And it is not merely that life is preserved. The lengthening of years is of little value if the late years of life are a mere exhibition of prolonged uselessness. With the prolongation of life through careful living, there goes the prolongation of faculties. We have the acquaintance of many men of advanced years, some of whom have served in great public offices, who, although over seventy-five years of age, hold themselves upright, and are not only able to work, but eager for work, and who retain the greater part of their faculties unimpaired. The value of such lives to their owners and to the public cannot be exaggerated. The man who at seventy-five or eighty years of age is able to exercise an intellect which is enriched by more than two generations of experience, and by long participation in affairs, is a senator of his kind, whose success in life, presently to be rounded with a sleep, is maintained until the close.

Metchnikoff has told us that man can learn to prolong his years far beyond what is now regarded as their natural span. However that may be, it has now been clearly proved that the traditional "three score years and ten" is by no means to be regarded as a normal period. The average youth can legitimately hope to do better, and to live to enjoy a frosty but kindly eighty, or even ninety, years. There can be no question that the general good of mankind would be served by a general prolongation of the life of individuals. The loss of an experienced life is a very real one, and it would have gone hard with mankind if the brevity of life had not been compensated for by the making of records which enable one generation to pass on its acquired knowledge and experience.

In spite of the great treasures that we have written for us in our books, however, the world would gain if normal life were prolonged for three generations, and if we had among us a larger number of healthy, vigorous men with an adult experience of two generations. If we take the age of puberty as the beginning of what one may call intelligent outlook upon the world, a man of fifty has behind him only a little more than a generation of useful experience, and at sixty-five only half a century of such experience. If a large proportion of men lived to be eighty-five, and were as useful to the end as some living men we know, we could call to our aid the wise assistance of many individuals with seventy

years of practical knowledge of the world to guide them and us. As for the individual, it cannot be doubted that the possibility of living to see results is a great spur to endeavour. "Not in our time" is by way of being a depressing thought. The young man of twenty-five, working and hoping for a great end, will work all the more ardently if he has the prospect of not leaving the field of his labours until his eyes have seen.

It should be, therefore, part of the early aim of the individual to acquire a good working stock of health. Fortunately, this is becoming a matter ever less difficult of achievement. Knowledge of the laws of health is becoming more widespread, and excess in eating and drinking is no longer condoned by society. As far as the great mass of the people are concerned, however, much has yet to be done by way of rebuilding our towns before the full heritage of life can be taken up by the million. We have but to study the statistics relating to the expectation of life as between a rich and a poor district to realise how many years of life are robbed from the life-span of the many. If what we have said as to the value of the prolongation of life is true, it follows that it is a national duty to demolish the congested districts of our cities and to empty our crowded townships into new and better quarters, carefully and thoughtfully constructed on the outskirts of our present absurdly restricted town areas.

The healthy enjoyment of life is by no means the same thing as success in an aim or profession. If a man is to make a success of his life in the best sense he must seek width of interest and catholicity of taste. It is, of course, impossible for the modern man to work professionally with success in more than a limited sphere. It is probably true that it is now necessary to specialise if one is to do work of real value. Nevertheless, specialisation in a particular line of endeavour does not forbid a general and all-round acquaintanceship with science and with affairs. Indeed, it adds to the value of the specialist's work if he knows it for what it is—part of the whole field of work.

The cultivation of a wide field of interest in life makes a man's days full, and banishes the possibility of boredom and ennui. The properly cultivated man is never at a loss for what to do with a day or with an hour of leisure. His difficulty is rather to choose between many excellent alternative methods of spending the time. He has so educated his natural powers that life offers him innumerable matters of interest to give him fruitful and varied occupation. There are exceptional cases, of course, in which a man is inherently incapable of appreciating music, or line, or colour, but in the ordinary case the individual has many and varied powers of enjoyment, which he owes it to himself to educate and develop.

The normal man should be capable, if not of original creative work in drawing, at least of the power of appreciating drawing. Equally the normal individual should know good literature or music from bad, and, to pass from the arts to the sciences, the normal man should think it shame to be part of a civilisation based upon scientific work without understanding the methods of that work and the elementary principles upon which it is founded. The normal man can easily know these things, and can understand the world which he inhabits. It is not making a success of life to accumulate wealth during long years by buying and selling at a profit, and at the end of the money-making years to be stranded useless, without culture or understanding, merely to decay upon the heaps of one's own accumulations.

The width of a cultured man's interest should include the domain of public affairs. As nations progress that domain is ever widening, and the individual, therefore, who refrains from cultivating a lively interest in public questions will find himself shut out of an ever-widening sphere of thought and action. The "proper study of mankind is man," and he is something less than a man who neglects to study men in their collective or public actions. There are those who disdain the political world as being at the best useless, and at the worst corrupt. It is surely the duty of those who despise existing political methods to show a better way, and it is necessary always to suspect one's opinions when they tend in the direction of despising the actions of men who cannot be wholly unlike ourselves. In public affairs the practical course has to be taken in some direction expressing the greatest common measure

of agreement that can be arrived at between people who cannot possibly think exactly alike. When such a course is taken the man unversed in affairs is sometimes tempted to sneer, in forgetfulness of the necessity placed upon those who rule a nation to act in such a way as to reconcile conflicting interests and to seek the general good without inflicting individual hardship. Be that as it may, however, no individual life can be full or complete which does not take its part in working out the public problems of its day and generation, or which resigns to others all lot and part in helping to shape a nation's destinies.

The wider the cultivation of the faculties, the less need for reliance upon what may be called professional amusements. The art of successful living, if properly studied, should make the home a place both interesting and amusing. It is unfortunately true that the majority of homes are necessarily made in temporarily rented places in which it is difficult for the home-makers to develop the arts of domestic happiness. It is only the minority of houses which have garden-places worth the name, and it is pitiable that one of the simplest and best of all pleasures should be denied in whole or part to so many millions of the sons of Adam.

It may be laid down as a general maxim that the larger the proportion of a man's income spent upon his home, the greater the income of satisfaction he will obtain from his spending. Among the conceptions which have advanced during the last few generations, that of the home has perhaps fared worst. Very many things could be named in which there has been most conspicuous improvement in the last half-century, as, for example, in the production of books and journals, in the materials and fashioning of dress, in the means of locomotion. The house, however, has not made the same advance. This is partly due to the fact that a house is a structure of some permanence, and it is only in the new house, rarely built, that there is a chance of making much real advance. Even new houses, however, show little signs of improvement, and in many respects, as for example in the size of gardens, the new houses are worse than the old ones. The man, therefore, who desires to make the most of his life will do well to give special attention to his home. He will find the subject well worth study, and investigation will show him that it is possible even with a moderate income to do very much better in the way of home-making than is usually done. It is a matter in which the individual must be enterprising and resourceful. He must be prepared to search widely, to find a suitable situation, and to sacrifice some things for a few years in order to acquire a satisfactory permanent framework for his family life. If he cares to do this, he can add an element of success to his years which no other form of effort can give him. He can make his home and his garden so beautiful and attractive, no matter on how small a scale the thing is done, as to give him a very real feeling of having a place in the world.

The successful home is a prime element in the successful life, and it can only be an expression of cultured and resourceful minds which find within themselves the means of happiness. A well-furnished home does not mean a home of costly decoration; it means a home in which there are books and instruments and tools of recreation or sport or amusement which are in constant use and yielding an ever-increasing dividend to their owners.

It is impossible to consider the all-important relation of the home to success in life without being constantly reminded of the lamentable fact that the great majority of the people of the United Kingdom are badly housed. The majority, we repeat, have no definite home-place. There are districts in the capital where a Parliamentary representative, at the end of a Parliament, finds new faces in a very large proportion of the houses of many poor streets which he "represents." It seems very much like mocking millions of people to speak of making a success of home life. That reminds us that the happiness of a nation can only be the sum of the happiness of its families. We have much to repair in our social fabric before we can boast that we have made decent life possible for more than a minority of our people. It is not that a big or a rich home is necessary to success and happiness, but it is that a home, whether large or small, should have sufficient beauty and comfort, internally and externally, and sufficient continuity and permanence, to enable the finer virtues to take root and thrive.

L. G. CHIOZZA MONEY

The Lake District. The Pennines. The Principal Coalfields. The Midlands. The Thames Basin and Estuary. The Severn.

ENGLAND AND WALES

Along the Scottish Border are the Cheviot Hills, the link between the Southern Uplands of Scotland and the Northern Uplands of England. Their rounded summits rise to 2500 ft. To the south is the Eden Valley, with Carlisle, the centre of an agricultural district, controlling all routes north and south. The Shap Pass, about 1000 ft., leads from the Eden to the Lune basin and the plain of Lancashire. The Eden and Lune valleys almost separate the Cumbrian mountains of Cumberland and Westmorland from the Pennines proper, the Shap Fells uniting the two in the centre. The Lake District is a district of bare mountains, often with terrible precipices, and long valleys filled by beautiful lakes. Innumerable streams, fed by the constant heavy rains from the Atlantic, course down the mountain sides, leaping from crag to crag in the waterfalls for which the district is famous. Skiddaw, rising above Lake Derwentwater, Scafell, above Wastwater, and Helvellyn, near Ullswater, the grandest of the lakes, are all over 3000 ft. high. The climate is too wet and cold and the soil too scanty for agriculture, but there is much sheep-farming. Summer brings thousands of tourists, who congregate at Keswick, on Derwentwater, and at Ambleside, by Windermere, the largest of the lakes. Kendal, once famous for its woollens, manufactures friezes, procuring its coal by canal from the Lancashire coalfield.

The Pennines run from the Scottish Border far into Derbyshire, with lowlands on either side extending to the sea. They are separated from the Cheviots by the Tyne Valley in the north, and are divided into two masses by the Aire Valley in the centre. The scenery varies with the character of the rocks, and is most picturesque in the limestone. Much of the Pennines consists of hill pastures, diversified by heather moors, and mosses or bogs. The highest points—Cross Fell, Bow Fell, Whernside, and Ingleborough—all north of the Aire, are between 2000 and 3000 ft. The picturesque Peak District of Derbyshire to the south is just over 2000 ft. Here the rock is limestone mixed with millstone grit, a name which explains itself. The edges form wild, craggy cliffs, with deep river gorges winding far back into the heart of the plateau. The upper surface is covered with a considerable thickness of peat, through which bosses of grit project, which have been worn into wild and fantastic forms. In the limestone districts of the Peak are immense caves, numerous underground rivers, and steep-walled dales, like Miller's Dale, near Buxton. Mineral springs occur at Buxton and Matlock in the Peak, at Harrogate and Ilkley in Yorkshire, and elsewhere in the Pennines.

On either side of these lonely uplands are busy industrial regions, darkened by day by the smoke of mill chimneys, and lit up at night by the glare of blast furnaces, all fed by the coal which abounds on both flanks of the Pennines. The iron industry in all its many branches, including shipbuilding on the coast, is very general. Cotton, brought across the Atlantic to Liverpool, and, since the cutting of the Ship Canal, to Manchester, is manufactured on the South Lancashire coalfield. In the Yorkshire valleys opening from the eastern Pennines woollen manufacture is important.

The Cumberland coalfield extends along the sea from Maryport to Whitehaven, the workings round Workington being carried under the sea. To the south, in the rugged Furness district of North Lancashire, on the margin of the Lake District, the abundance of red hæmatite iron has created the town of Barrow, which, 50 years ago, before the invention of the Bessemer process, was a fishing village. Among its many iron industries are smelting, shipbuilding, and the manufacture of ordnance, some works being on Walney Island, off the coast. Barrow is a busy port, and has steamer services to Irish Sea ports.

Lancashire is flat and sandy along the coast, but rises to over 2000 ft. in the north and east. Except on the coalfield, which covers 400 sq. miles between the Ribble and the Mersey, it is pastoral in the

uplands, and agricultural in the lowlands, raising potatoes and oats. Lancaster, the county town, is hampered as a port by the silting of the Lune estuary. Heysham and Fleetwood, on the shallow Morecambe Bay, are ports and packet stations. Blackpool and Southport, north and south of the Ribble estuary, are crowded seaside places. At the head of the Ribble estuary is Preston, with important docks, engineering works, and cotton mills. Its frequent horse and cattle sales indicate its position on the margin of the agricultural region.

Crowded on the coalfield to the south, and engaged in manufacturing cotton or iron (machinery, railway plant, and the like), or both, are Clitheroe, Burnley, Blackburn, Bury, Bolton, Oldham, Warrington, and Manchester, with Stockport and Stalybridge over the Cheshire border. St. Helens makes chemicals. Manchester, the industrial capital of Northern England, is less a manufacturing centre than a market. Its rival is Liverpool, with Birkenhead, near the mouth of the Mersey estuary, the focus of Transatlantic trade and passenger traffic Both the Liverpool and Birkenhead sides of the estuary are lined with docks and warehouses, which receive not only cotton, but grain, tobacco, leather, live and dead meat, and whatever the Atlantic coasts of the New World have to send, and produce from other parts of the world.

The Cheshire Plain and North Staffordshire Coalfield. The Cheshire plain, an extension of the Central English plain, opens a way between the Pennines and the Welsh mountains. Except on their margin, it is an undulating meadow region, noted for cattle and dairy produce, including Cheshire cheese. Coal crops out in the east on the Peak margin, where silk and cotton are manufactured round Macclesfield. Rock salt is worked round Northwich, Nantwich, and elsewhere. Coal becomes more abundant in North Staffordshire, where it supplies the five Pottery towns now incorporated as one city—Stoke-on-Trent.

Northumberland-Durham Coalfield. Both Northumberland and Durham are rugged in the west, where Cheviot sheep and Durham cattle are bred. In the valleys opening to the lowlands, barley, wheat, beans, turnips, and potatoes are grown in the rich clayey loam. Fishing towns and ports for coasting traffic dot the coast. The chief river is the Tyne, with two head streams, North Tyne from the Cheviots, and South Tyne, which has cut a valley across the Pennines, followed by the line from Newcastle to Carlisle. At its estuary are the Tyne ports, Newcastle, Tynemouth, Jarrow, and South Shields, the outlet for the manufactures of the rich coalfield. These include iron in all branches, hemp and wire rope, glass, chemicals, and pottery. Much coal is exported. Newcastle, with Gateshead on the opposite bank, is engaged in all these industries. At Elswick, a suburb, are the Armstrong ordnance works, where the most powerful guns are made. Sunderland and the Tees ports, Stockton and Middlesbrough, are similarly engaged in working up the iron which abounds in the Cleveland Hills of North Yorkshire. The combination of cheap coal and iron is rapidly attracting shipbuilding away from the Thames, where freight makes both costly, and concentrating the industry on the Tyne and Tees. Darlington manufactures woollens and carpets, as well as iron and steel. In striking contrast to these smoky industrial towns is Durham, on a height above the Wear, with a glorious cathedral and old-world streets.

The York, Derby, and Nottingham Coalfield. The eastern slopes of the Pennines are drained by a series of parallel rivers, Swale, Ure, Nidd, Wharfe, Aire, and Calder, whose valleys gradually widen from narrow dales of wild beauty to broad and fertile lowlands. In these valleys, as in the Tweed basin, where the conditions are similar, the woollen manufacture has long been important. The wool was supplied by the hill pastures above, and the river was there to turn the mills. Now, especially in the Aire and Calder valleys, water power is replaced by steam. The Yorkshire coalfield, between the Aire and the Don, covers an area of forty-five miles by twenty. The chief woollen towns are Keighley, Leeds, Bradford, Huddersfield, Halifax, and Dewsbury. Linens are made at Leeds and Barnsley. Cutlery, electro-plate, armour, guns, and hardware are made at Sheffield, near the borders of Derby and Nottingham. In these counties, both rich in coal, the Pennine landscape gradually gives place to that of the plain. On the Derbyshire field collieries disfigure many a lovely valley. Silk is manufactured in Derby, and brewing is important at Burton. On the Nottingham field the manufactures are lace and hosiery, carried on at Nottingham, on the Trent.

The Vale of York. The rivers named above unite to form the Ouse, the main stream of which flows across the rich Vale of York parallel to the base of the Pennines. From the east comes the Derwent, flowing between the Yorkshire moors, rich in iron, and the Yorkshire wolds. The Vale is very fertile, and both agriculture and dairy farming are important. It is dotted with prosperous market towns. York, on the Ouse, with remains of the Roman city and a magnificent cathedral, is the focus of the district, and the seat of an archbishopric. In the rugged east, the towns are found along the coast, which, as far as Flamborough Head, is high and picturesque, and dotted with seaside resorts, of which Whitby and Scarborough and Bridlington are the most popular. South of Flamborough Head the low district of Holderness grows fine crops of wheat, beans, and hay, while barley and turnips do better on the wolds.

On the Humber, the broad estuary of the Yorkshire Ouse and the Trent, are Goole, Hull, and Grimsby (in Lincolnshire), busy ports. Hull, besides an enormous trade by sea, builds ships and carries on a large number of flourishing industries. The proximity of the Dogger Bank makes the fisheries important all along the coast. Hull and Grimsby are the chief centres.

From them fish-trains run to the inland towns. Hull, Grimsby, and Goole trade chiefly with the

North Sea and Baltic ports, exporting coal, woollens from Yorkshire, cotton from Lancashire, and even raw cotton and rubber bought from American or African ports to Liverpool for towns on Baltic or North Sea shores of the Continent. Of the imports, note butter, from the meadows of Denmark and Holland, and timber, from Scandinavia and the Baltic. The trade of these ports is thus an instructive commentary on its geographical position. The reader should similarly endeavour to think out for himself the actual or possible relations of his own district to the larger world without.

The English Plain. We now pass from the uplands to the lowlands of England. In the north they are cloven by the Pennines into the Lancashire and Cheshire plain in the west, and the plain of Yorkshire on the east. South of the Pennines they extend from the base of the western mountains to the North Sea, broken by occasional lines of heights. Here the population is concentrated, densely on the coalfields, more sparsely in the agricultural districts. The plain, outside the coalfields, is dotted with numerous towns, many very ancient, sometimes with manufactures of some importance, but always the focus of the traffic, trade, and political life of the surrounding district. Before the days of railways, many, like Birmingham, Coventry, and Norwich, had a very intense local life, and a highly intellectual society. Now London attracts the best elements, and provincial life is correspondingly modified.

The Lincolnshire Fenlands. Lincolnshire occupies the angle between the Humber and the Wash. Much of it is a low plain, largely composed of fenland. Many canals and dykes have been cut to drain it, and along the sea it is often embanked to keep the sea out. In the centre the chalk, which covers much of southern England, crops out in the Lincolnshire wolds, rounded hills with sheep pastures, and farther west in the ridge of Lincoln Edge. Famous breeds of horses and cattle are kept in the rich, moist, low-lying meadows. Corn is largely grown.

Some Typical Towns. Lincoln, the county town, an ancient city with a fine cathedral, is built on a height, where the Witham cuts through the Lincoln Edge and becomes navigable. Its industries illustrate the relation of such a town to the district around. Its ironworks and manufactures of farming implements and machinery show how the needs of a farming country create local industries to supply them. Its steam flour-mills and breweries show how agricultural produce is locally worked up. In spring, a horse and cattle fair lasts several days, and there are frequent corn, wool, and stock markets. This illustrates the distributing centre.

The Foss Dyke, from the Witham, near Lincoln, to the Trent, connects the counties of the Trent basin with Boston, on the Wash, at the mouth of the Witham, a fishing port, exporting grain, and manufacturing sailcloth, leather, and ropes. Such industries, as well as boat-building, are found in almost every coast town. Fishing is important all along the coast.

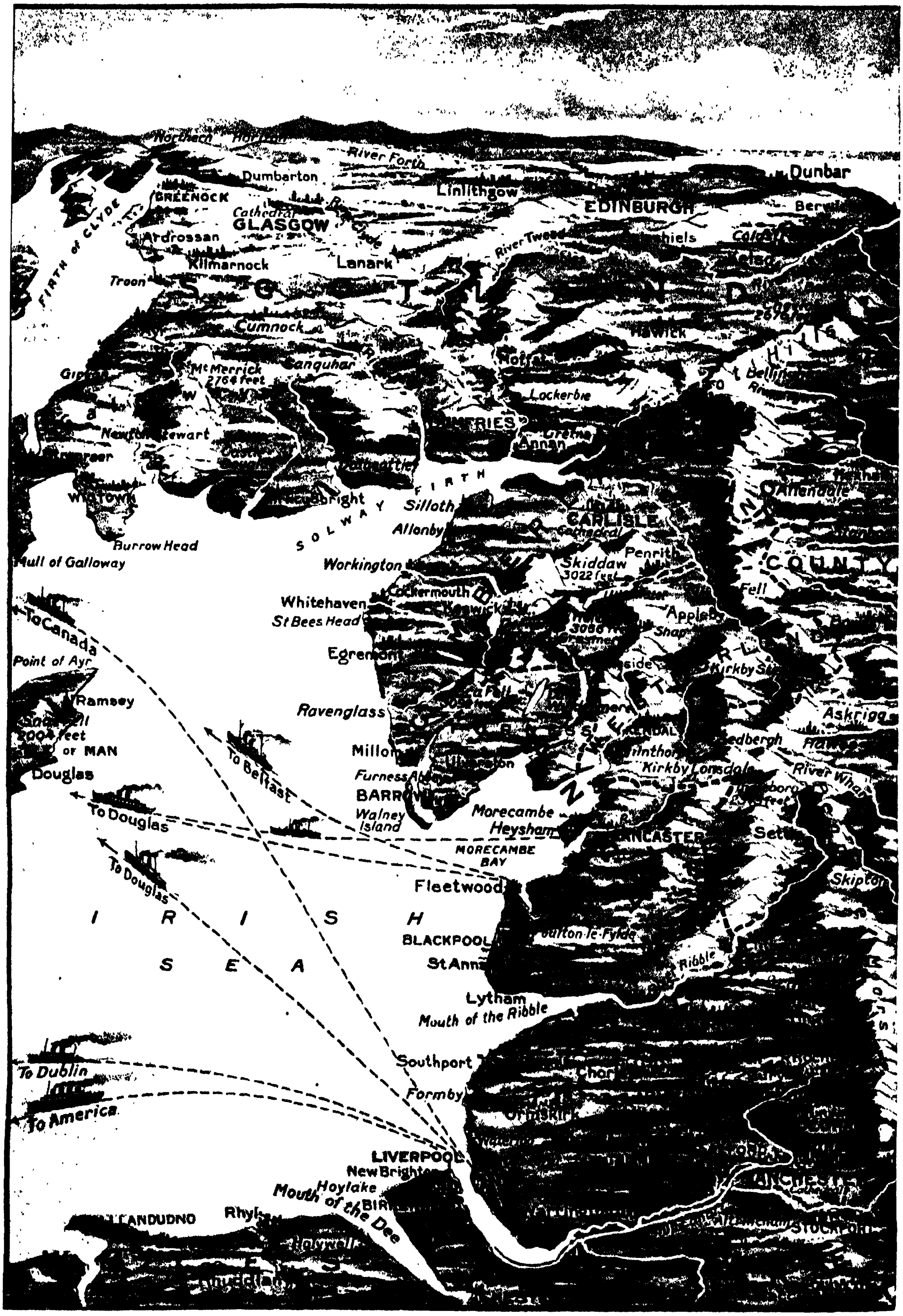
A sub-port of Grimsby, collecting its exports and distributing its imports, is Gainsborough, on the Trent, an inland town on the map, but really built where the river is still tidal. Here Baltic timber is stored in timber-yards, or sawn in saw-mills, while other commodities are shifted from steamer to barge, or vice versa, for the Trent is one of the great arteries of eastern England. It rises in the western Pennines, and flows round their base, receiving many tributaries, of which those from the Peak come down in lovely parallel dales and valleys. It is navigable as far as Burton, the famous brewing town, in the very heart of England, which is thus, by means of the Trent and the canals connected with it, brought into direct communication with the sea.

The Midlands. Under this term we may include the shires of Northampton, Rutland, Huntingdon, Bedford, and Cambridge—drained to the Wash—Leicester and Stafford in the Trent basin, and Warwick in the Severn basin, the two latter containing the Midland coalfield. The east is the richest agricultural district of England. Of the rest, much is in grass, forming ideal hunting country, hunted by many famous packs. It is separated from the Thames basin by the Cotswold and Chiltern Hills, with lower heights between. In the east, the Welland, flowing past Stamford, the Nen, past the cathedral city of Peterborough, and the Great Ouse, past Bedford, St. Ives, and the cathedral town of Ely, all rising at no great elevation, flow sluggishly to the Wash. Much of their basins consists of marsh and fen land, reclaimed at great expense by cutting innumerable canals and trenches, or dykes, and forming a rich, black mould of great fertility.

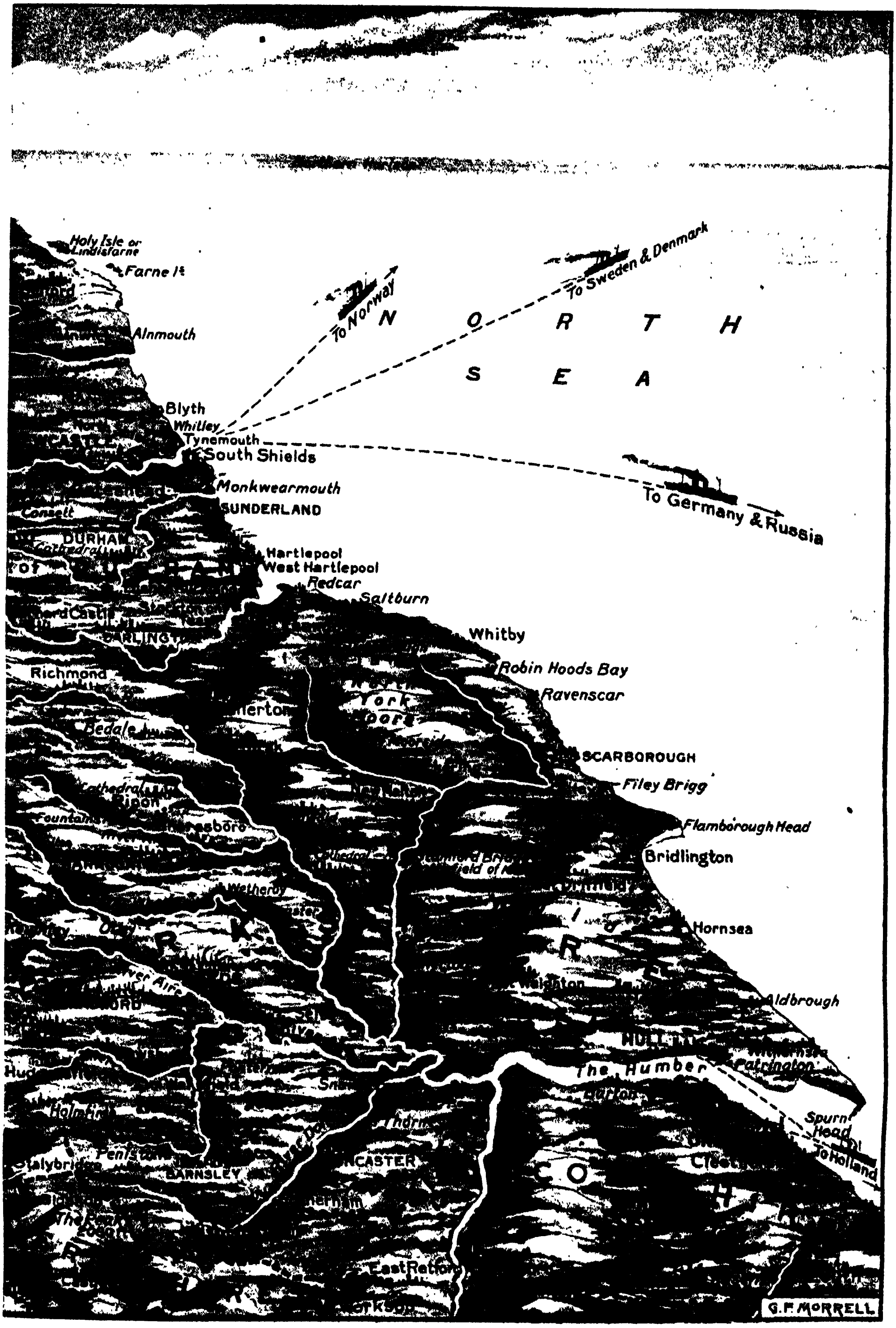
The so-called Isle of Ely, consisting of somewhat higher ground, was anciently entirely cut off by marshes, whence its name. It is now the centre of a fruit and vegetable growing district, with jam factories. Cambridge, on a tributary of the Ouse, is a university city with fine mediæval architecture. The basin of the Ouse contains some of the finest agricultural land in England, and wheat and other cereals are largely grown. Associated industries are straw-plaiting (Luton and Dunstable, in Bedfordshire), and brewing, which is very widely distributed. Dairy farming is almost as important. Stilton cheese is made near Melton Mowbray, in Leicestershire, and other associated industries are the fattening of cattle for the London market, and the boot and shoe industry of Northampton, Leicester, and Kettering. The very fine, long staple wool of the Leicester sheep makes hosiery an important manufacture at Leicester.

Shakespeare's Country. Outside the coal area, Warwickshire has the same character. The county town is Warwick, with a famous castle on the Avon, near Leamington, with mineral springs, the ruined castle of Kenilworth, and Stratford, the birthplace of our national poet. As Shakespeare's country,

THE INDUSTRIAL NORTH: FROM THE HUMBER TO



A GRAPHIC MAP OF THE NORTHERN PARTS OF ENGLAND AND THE LOWER PARTS
THE MOST WEALTH-PRODUCING



OF SCOTLAND, EMBRACING HUNDREDS OF SQUARE MILES OF WHAT IS PROBABLY AREA IN THE WHOLE WORLD

it attracts many tourists. The motor and cycle trade is important at Coventry. These counties, with their park-like landscape, golden wheat-fields, rich meadows, and ancient, somewhat sleepy towns, seem little changed by the coming of steam, and recall an England which has elsewhere largely disappeared.

The Midland Coalfield. Very different is the scene on the coalfields of North Warwickshire and South Staffordshire. Vegetation is blasted, and a pall of smoke overhangs squalid towns of mean houses, little redeemed by the fine administrative buildings and the luxurious villas of the west end—the fashionable, because, with our prevailing west winds, the least smoky quarter. Though known under different names, the various collieries all form part of one extensive field. Iron is everywhere abundant, and so is the limestone required as a flux. Iron smelting and the iron manufacture in all its countless forms are carried on in a ring of iron towns rapidly growing into one unsightly whole—Birmingham, West Bromwich, Smethwick, Wednesbury, Walsall, Wolverhampton, Bilston, Tipton, Dudley, and others—forming what is fitly called the Black Country.

East Anglia. East of the Midlands are the maritime counties of Norfolk and Suffolk, once part of East Anglia, with which we may include Essex outside the metropolitan area. All are, for the most part, flat, especially beside the sea, which encroaches on the land. Round the shallow Wash thousands of acres have been reclaimed. Beyond the Fen district, on the east coast of Norfolk, are the Broads, a region of shallow lakes and reedy marshes, teeming with wildfowl. Many rivers, rising in low heights to the west, flow east, opening to an estuary, with a port at the head, or mouth. Such are, among others, the Yare, with Yarmouth; the Orwell, with Ipswich; the Stour, with Harwich, the packet station for the Rhine and Elbe ports; the Colne, with Colchester. Similar in type, but called to a greater destiny, is the Thames, with London. the whole region is engaged in (1) agriculture, growing cereals and other crops, especially a fine malting barley; (2) grazing famous breeds of horses; (3) fishing, with its accompanying industries; and (4) the tourist industry, which is important all round the coast. The centres of the herring fishery are Yarmouth and the artificial port of Lowestoft. Of inland towns, note the cathedral city of Norwich, on a tributary of the Yare; and Chelmsford, on the Chelmer.

The Thames Basin. The Cotswold Hills, with lower heights to the north-east, separate the Thames from the Severn basin. They rise steeply from the western plain, exposing their bare limestone ribs, topped by short, dry pastures on which sheep are kept, and slope gradually to the south-west. The main stream of the Thames rises near Cheltenham, and receives the Cotswold streams, Windrush and Evenlode, from hilly pastoral districts, with small towns engaged in manufacturing the wool and skins they produce. Thus, gloves are made at Woodstock, and blankets at Witney, on the Windrush. Oxford is built where the Cherwell comes in, having risen in the Northamptonshire heights, and flowed almost due south. It is a famous university city of great antiquity and beauty.

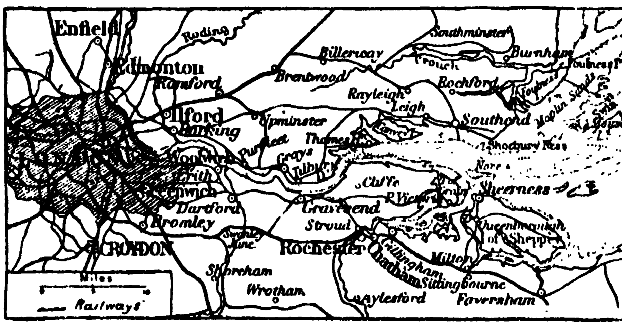
Beyond its confluence with the Thame, a few miles below Oxford, the Thames cuts through the chalk, separating the Chiltern Hills on the north-east from Marlborough, or White Horse Downs, on the west. At Reading it receives the Kennet, which flows in a valley between the chalk heights of Wiltshire and Berkshire. After passing near Windsor, with its famous Royal castle, the Thames receives tributaries from the Chilterns to the north. Flowing northward across the North Downs to the south, come the Wey, Mole, and Medway, forming gaps through these heights, which are used by the railways to the South Coast. In the picturesque lower reaches, Hampton Court, Richmond, and Kew are names familiar to Londoners. The houses grow more numerous, and the river widens, until at London Bridge it is nearly 800 feet wide.

London. London, like Oxford or Ely, was built originally among defensive marshes, on higher, firmer ground, and, like Glasgow, at the lowest point at which the river could be bridged. A little above it grew up the city of Westminster, round a much-used ford. The two are now continuous, but have separate administrative bodies. To describe London would require many pages. Its claims to rank as a beautiful city are based on (1) St. Paul's, in the City of London, rising above the Thames, not far from the Tower, an ancient fortress and former Royal residence; (2) the group of buildings fronting the river at Westminster, including the ancient Abbey and the Houses of Parliament, to which is now being added the palatial home of the County Council on the opposite bank; (3) a few fine streets opening west from Trafalgar Square, considered one of the finest sites in Europe; (4) the group of Royal parks in the fashionable West End. Beyond lies a wilderness of mean streets, extending miles in all directions. Beyond these, again, on north, west, and south, are pleasant suburbs. London is one of the great ports and markets of the world, and one of its chief financial centres. It is also the centre of national and imperial government, and the heart of our empire.

The Thames Estuary. In central London, the banks of the river are embanked and planted with trees, forming pleasant promenades. East of these come wharves, warehouses, docks, and the factories engaged in the many industries of a great seaport. Woolwich, on the right bank of the estuary, where the river is nearly twice as broad as at London Bridge, has an immense arsenal. Gravesend is a busy river port. Queenborough, on Sheppey, once an island, is a packet station for the Rhine ports. Shoeburyness, on the opposite bank, is a station for artillery practice. Sheerness, on Sheppey, strongly fortified, has barracks, dockyards, and arsenals. Chatham, at the mouth of the Medway, forming with the cathedral city of Rochester a single town,

is the naval arsenal. There are many cement and brick works in the neighbourhood. Farther east are numerous seaside resorts, Whitstable, with oyster fisheries, Herne Bay, Margate, and Ramsgate. Beyond Ramsgate, the chalk cliffs continue intermittently round the South Coast as far as Lyme Regis, on the borders of Dorset and Devon.

The Channel Counties. Nearly all the towns just named are in Kent, often called the Garden of England. The Weald, formerly covered with forests between the North and South Downs, is very fertile. Cereals, fruit, and hops are grown. On the North Downs fine sheep are bred. Towns are numerous, both inland and on the coast. Maidstone, on the Medway, in the centre of the hop district, has important breweries. Canterbury, on the Stour, with a magnificent cathedral, is the ecclesiastical capital of England and seat of the chief archbishopric. On the coast are the ports of Deal, Dover (an important naval centre), and Folkestone, the two latter Channel packet stations. Surrey, drained to the Thames by the Wey and Mole, which have cut gaps across the North Downs, has fine pinewood scenery. Sussex is drained to the Channel by short rivers cutting through the South Downs. Towns are numerous, especially on the coast. Notice Hastings, Eastbourne, the packet station of Newhaven, Brighton, and Worthing. Chichester, a cathedral city, is connected with the coast by a short canal. Hampshire, also a chalk county, is drained to the Channel by rivers flowing south from the Downs in the north. Note the indented coast, giving many good and two magnificent harbours.



THE ESTUARY OF THE THAMES

Portsmouth Harbour has an entrance $1\frac{1}{2}$ miles wide, and is our chief naval base in the Channel. It is very strongly fortified. Portsmouth is the garrison town, Portsea the naval dockyard, Landport the artisan quarter, and Southsea a watering place. On the opposite side of the harbour is Gosport. Portsmouth commands the entrance to Spithead, which, with the Solent, separates the mainland from the garden Isle of Wight, with the inland capital of Newport, and many summer resorts round the coast, including the yachting centre of Cowes. Both these straits open to Southampton Water, the Itchin estuary, with the great port of Southampton at its head. This is the packet station for most of our colonies and for the ports of the Indian, Pacific, and Atlantic Oceans. The largest liners afloat can enter and leave at all states of the tide. Bournemouth, with pine woods, is a winter resort. Inland, the chief town is Winchester, on the Itchin, with an ancient cathedral. It was originally the capital of England.

Dorset and Wiltshire. Dorset and Wiltshire form the south-western extremity of the chalk heights which cross the English lowlands. The rivers flow south, cutting gaps through the chalk heights. At most of these, towns are built, some, like the cathedral city of Salisbury, of great antiquity. These heights are known under many names, as, for example, Salisbury Plain, a moorland district on which is Stonehenge, an ancient stone circle. Grazing and dairy farming are important in the valleys, both Dorset and Wiltshire butter and bacon being famous. The sheep fed on the hill pastures supply wool to the woollen manufacturers of Trowbridge, Bradford, and other towns, carried on with coal from the British coalfields. Fishing and seaside towns line the coast, the most fashionable being Weymouth.

The West Country. Somerset is a transition county, resembling the Severn basin in the north, and in the Exmoor district passing into the scenery of Devon and Cornwall. It is a hilly county, with vales opening to the sea, the most fertile being the Vale of Taunton, famous for hops, fruit, and fine wheat. Bath is built on the gorge of the Avon, where excellent stone is quarried. Bristol, at the head of the Avon estuary, has long been a famous port. Early in our history it exported the wool of the surrounding sheep-farming counties, and supplied much of Catholic Europe with fish. The discovery of America increased its importance, and it now trades with every part of the world, especially across the Atlantic. Among its many manufactures are tobacco, cacao, sugar refining, boots, all depending on its imports. Shipbuilding, engineering works, chemical works, and soap and glass making are among its other industries.

Devon and Cornwall. Devon and Cornwall are maritime counties. Much of the interior is high, bleak moorland, forming the highlands of Dartmoor (1700 ft.), with hardy breeds of ponies, sheep, and cattle; Exmoor, where deer are still semi-wild; and Bodmin Moor. Round these centres woollen towns tend to grow up, as at Axminster, in South Devon, where carpets are made. Honiton, not far off, makes lace. In the steep-sided valleys opening from the highlands the red earth is very fertile. Dairy farms and orchards supply Devonshire cream and Devonshire cider. The rivers enter the sea by picturesque winding estuaries, each with its fishing town. Notice Barnstaple in

North Devon; and in South Devon, Axmouth, Sidmouth, Exmouth on the Exe, with the cathedral city of Exeter, the capital of the West Country, higher up the river; Teignmouth, Dartmouth, and especially Plymouth, built where the Tamar estuary forms Plymouth Sound. With Stonehouse and Devonport, Plymouth ranks next to Portsmouth as a naval station, and rivals Southampton in its world-wide communications.

Cornwall prospers mainly by its fisheries and its tourist traffic. The tin and copper mines famous in antiquity still yield a little, and radium is got from pitchblende. The towns are chiefly on the coast. Falmouth harbour, with Falmouth at the mouth and Truro at the head, recalls Plymouth Sound. Penzance and St. Ives lie in the extreme south-west. The Scilly Isles, 150 in number, but few inhabited, engage in fishing and in growing early vegetables and fruit.

The Severn Basin. The Severn rises in a small lake on Plynlimmon, in the heart of the Welsh highlands, whose sheep pastures feed the woollen towns, Newtown and Welshpool. Shrewsbury, commanding the route across Cheshire into North Wales, had one of the many castles built along the Welsh Border, or March, of which Ludlow, Monmouth, and Chepstow may also be mentioned. The Severn flows through a picturesque district, between the Shropshire and Stafford heights, where coal and iron are worked in Coalbrookdale, and some wool is manufactured, as at Kidderminster, and then enters a broad vale between the Malvern Hills and the Forest of Dean on the west, and the steep Cotswolds on the east. On the right bank picturesque tributaries descend from the Welsh highlands. The Teme flows past Ludlow, and enters the Severn not far below the cathedral city of Worcester, with famous porcelain works. The Wye, from Plynlimmon, rivalling the Rhine in beauty, flows by the cathedral city of Hereford, in a hop and orchard country; Monmouth, Tintern, and Chepstow to the Severn estuary, which the Usk, with Newport as its port, also enters. On the left bank sluggish streams cross the central plain from low heights which separate the Severn basin from those of the Trent and the Wash rivers. The Avon, the largest, flows by Warwick and Evesham, in a rich orchard country, to the Severn at Tewkesbury. Wool is manufactured in Stroud and other Cotswold towns with coal from the Forest of Dean, which also supplies Worcester. Cheltenham has mineral springs and famous schools. Gloucester, at the head of tidal navigation, with a fine cathedral, is a port. The Severn Bridge, nearly a mile long, crosses the estuary at Sharpness, and further south a tunnel, 4½ miles long, carries the lines for Wales below the bed of the river.

The Land of Mountain and Song. Much of Wales consists of mountains, many over 2000 feet high, with the longer slope and longer rivers to the east, and the short slope and shorter rivers to the west. North Wales is higher, bleaker, and more thinly peopled than South Wales, where the lowlands are more extensive, and coal and iron are abundant.

North Wales. North Wales consists of the counties of Anglesey, Carnarvon, Denbigh, Flint, Merioneth, and Montgomery, nearly all rugged. In the north-west Snowdon rises to over 3500 ft., with magnificent precipice, lake, and valley scenery. The Conway valley, with Conway, and the fertile Vale of Clwyd, with Rhyl, open to the northern lowland. Between the two is Llandudno, crowded with visitors in summer. The lowland is broadest in the island of Anglesey, separated from the mainland by Menai Strait, crossed by a tubular bridge, with Bangor and Beaumaris on opposite sides of the strait. Holyhead, situated on Holy Island, west of Anglesey, is the mail-packet station for Ireland.

An important break in the mountains of North Wales is made by the Dee, which rises at just under 3000 ft. near Bala Lake, the largest in Wales. It opens to the Flint lowland, with the collieries of Ruabon and Wrexham, and leads to the English border at Chester, not far from the head of the estuary, which commands the route to the English plain, and has been important since Roman times. Its ancient streets, with their covered arcades, and its mediæval walls and towers, preserve for us a typical Old English city.

The West Coast. Here we find the familiar occupations of fishing and catering for summer tourists carried on by Aberystwith and many other towns, each at the mouth of a picturesque valley opening to the sea. The same type continues along the South Wales coast. Summer brings prosperity, the winter usually privation and much loss of life in the south-westerly gales.

South Wales. South Wales consists of Cardigan, Pembroke, Carmarthen, Glamorgan, Brecknock, and Radnor. The highest parts are in Cardigan, where Plynlimmon separates the Severn and Wye from the rivers flowing east and south, and in Radnor and Brecknock, where the mountains rise to over 2000 ft. On the west coast are Cardigan, at the mouth of the Teifi valley, and Fishguard, the packet station for Rosslare, in Ireland, and a calling place for Atlantic liners.

A broad lowland fringes the south coast, treeless in the west, where it fronts the Atlantic gales, but rich and fertile in the Vale of Glamorgan. The coast is deeply cut into bays, the finest harbour being Milford Haven, on which is Pembroke, with dockyards. Tenby is a noted watering-place. Long, parallel valleys descend to the coast of the Bristol Channel; the Tawe, with Swansea; the Neath, with Neath; the Taff, with Cardiff, and others. In the west sheep-farming is the chief occupation, but in Glamorgan the valleys are alive with colliery and furnace. The South Wales coal is specially good for smelting and for steam coal, and immense quantities are exported, much for naval purposes, from Llanelly, Swansea, Cardiff, Barry, and smaller ports. Iron is abundant, but of poor quality, and the great ironworks of Merthyr Tydvil, and the copper-works of Swansea, are largely fed by imported ore brought to the ports at the valley mouths.

A. J. AND F. D. HERBERTSON

Characteristic Features of the Gothic Ideals and the Buildings in which They are Seen

GOTHIC ARCHITECTURE

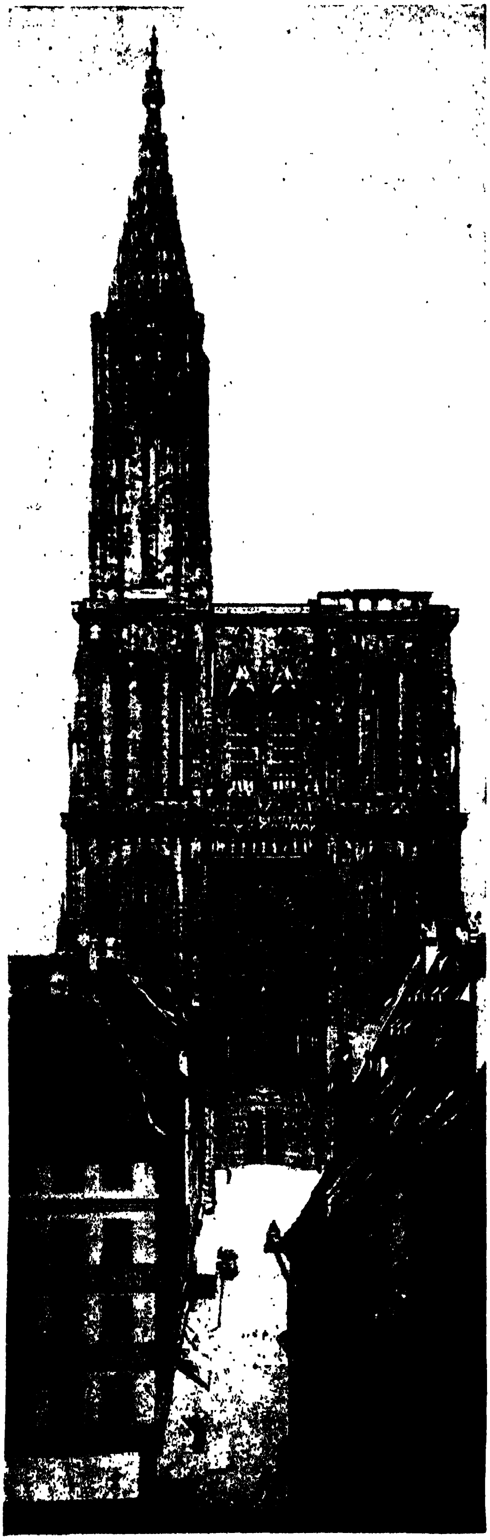
THE term "Gothic" as applied to art does not signify a style introduced by the Goths, but was first used by the Italians of the Renaissance more or less as an opprobrium, as a synonym of "barbarous," with reference to the artistic style of the despised Northern nations at a time when all true culture was thought to be necessarily founded on the antique.

Just as the round arch is typical of the Romanesque, so the pointed arch is the characteristic feature of the Gothic style of architecture. Yet it is at times difficult to draw the line which separates the one from the other, as the pointed arch was not entirely unknown in Romanesque architecture, especially in the regions which were in direct touch with the Saracenic race. Moreover, the transition from the one to the other was gradual, and many twelfth-century churches show elements of both styles. The pointed arch was at one time believed to be the invention of the Northern mind, but there is no doubt now that the principle was derived from Saracenic sources, though the full development of its possibilities must be put to the credit of the builders of mediæval France, England, and Germany. In the Orient the pointed arch had been used as a playful ornament to relieve the monotony of bare walls. In the North it was developed into a new architectural system, which, through the subordination of the allied arts to architecture, had a decisive influence on the course of sculpture and painting.

Stability is the most important consideration in architecture, and the necessity of structural soundness leads to the logical development of every style in building. Thus the weight of the barrel vaults demanded solid, heavy masonry in Romanesque buildings, since the whole pressure of the domes and vaults had to be carried by the walls. Hence the preponderance of solid masonry over the openings. The Gothic vault, based as it is on the pointed arch, relieves this pressure by distributing it over the projecting ribs, which rest on strong piers or pillars, and consequently gives wider scope to the articulation of the walls. Gradually the solid masses of masonry disappear, until the openings for doors, windows, rose windows, etc., are more in evidence than the walls. But though the actual weight of the vaults finds sufficient support in the piers, the lateral pressure, or thrust, of the pointed arch demands a new counteracting member—the oblique prop, or "flying buttress," which is so distinguishing a feature of the exterior of Gothic cathedrals. The "flying buttress" again needs the support of the vertical buttress, weighted down by the pinnacle.

It might thus almost be said that in the Romanesque style the decorative features are conditioned by the structural system, whilst in the Gothic style a new structural system is the necessary outcome of a new decorative feature. Or, in other words, stability was the law of classic and Romanesque architecture, and elasticity or balance of the Gothic. In Gothic vaulting, for instance, the ribs, an essentially decorative feature, are the important element, and the curved surfaces of the vaults may be removed without affecting the structure. In the Roman vaults the ribs have no structural function, and would collapse with the removal of the curved surfaces. As walls decreased in massiveness, the horizontal gave way to a vertical tendency in the buildings, which rose to loftier heights, the eye being carried heavenwards by the serried vertical lines of the buttresses, turrets, pinnacles, and the crowning glory of the tall spire. It is this striving towards the infinity of space that makes the Gothic cathedral the noblest expression of the lofty aspirations of Christianity.

Another result of the adoption of the pointed arch was the possibility of varying the height of the arch regardless of its width, a liberty which was not allowed by the semicircular arch. This did away with the necessity of square compartments, which prevailed in Romanesque vaulting; the nave could be given the same number of compartments as the aisles, which again left greater freedom to the play of fancy in the plain, and the general effect of the interiors became



STRASBURG CATHEDRAL

more varied and animated. The profuse use of stained glass helped to enrich the interior, whilst the exterior allowed the full play of inventive fancy in the countless carved stone traceries and ornaments, statuettes and reliefs and pinnacles, which, in course of time, transformed the whole building into a lace-like, gossamer web of stone tracery and sculptured ornament. To show the extent to which this applied decoration was carried, it is only necessary to state that the reliefs, statuettes, and stained-glass windows of Chartres Cathedral alone contain some 10,000 figures, and that the exterior of Milan Cathedral carries upwards of 2000 statues carved in marble.

The two countries in which the Gothic style received its first impetus and reached its highest efflorescence are France and England. In both countries Gothic architecture flourished from the thirteenth to the end of the fifteenth century, and may be divided into three periods, though the development proceeded on different lines on the two sides of the Channel. In France the three successive centuries coincide approximately with the Primary, or *Gothique;* the Secondary, or *Rayonnant*, so called from the wheel tracery of the rose windows, and the Tertiary, or *Flamboyant* style; in England with the *Early English*, the *Decorated*, and the *Perpendicular* styles.

Of the earliest style in France the first example of typical Gothic construction is the church of St. Denis, near Paris (1144). A little later in time, but thoroughly characteristic of the first period, are Notre Dame of Paris, and the Cathedrals of Rheims, Bourges, Chartres, Amiens, and Rouen. The wars with England acted as a check to French building activity in the fourteenth century, of which period St. Ouen at Rouen, and the unfinished church of St. Urbain at Troyes, are the most typical examples, whilst the Flamboyant development of the fifteenth century is best represented by St. Maclou at Rouen. During the close of this epoch secular architecture also advanced with rapid strides, and produced such masterpieces as the Palais de Justice at Rouen and the Hôtel de Jacques Cœur at Bourges.

The Early English and Decorated Styles. Early English Gothic can best be studied at Salisbury Cathedral, and in parts of Westminster Abbey—the choir transepts, and first five bays of the nave. Noble proportions and simplicity in decoration are the chief aims of the period. The Decorated or fourteenth-century style is recognisable in the interior by a more complex system of vaulting, and on the exterior by the larger clerestories and window openings and the increased splendour of the tracery. Some of the cloisters in Westminster Abbey, the Chapel of St. Etheldreda, in Ely Place, Holborn, and parts of the Cathedrals of Ely, Lincoln, York, and Lichfield may be quoted as notable examples.

The Perpendicular style of the fifteenth century has its name from the increased stress laid on the vertical line, which predominates to such

an extent that one almost loses consciousness of the existence of walls. The clerestory windows increase in size so much that no room can be found for a triforium, and they have to be strengthened by double mullions. Very often the stonework is reduced to a mere skeleton to hold the glass. Open timber roofs, richly carved and ornamented, are of frequent occurrence in the earlier Perpendicular period; whilst "fan-vaulting"—so called from the similarity of the ribs to the framework of a fan—is characteristic of the later period. This fan-vaulting is a peculiarly English motif, and only very rarely found in other countries. The dazzling splendour of its effect is known to everybody who has been in Henry VII.'s Chapel in Westminster Abbey. St. Margaret's, Westminster, St. George's Chapel, Windsor, Westminster Hall,' and the west fronts of Winchester and Gloucester Cathedrals are instances of Perpendicular Gothic.

Germany, where the Romanesque style had taken very firm root, was comparatively reluctant to welcome the new ideas which were introduced from France. Cologne Cathedral, which was begun in the middle of the thirteenth century, is almost identical in plan with Amiens Cathedral. The cathedrals of Strasburg, Ratisbon, Treves, Vienna, Ulm, and the beautiful churches of Nuremberg are among the chief monuments of German Gothic, whilst numerous castles, such as that of Marienburg; town halls—Ratisbon, Brunswick, Münster, Lübeck—and private dwellings, of which many are still to be seen in Nuremberg, Cologne, and other old cities, testify to the artistic taste which prevailed in secular architecture. In domestic architecture the most characteristic features of the German Gothic are the very high and steep gabled roofs, which often exceed in size the actual walls, and the pretty dormer windows. Frequently the upper storeys project over the ground floor. The ridge of the roof is either parallel to the street or at right angles to it. All these features combine to give an extraordinarily picturesque and quaint effect to the narrow streets of these cities.

Some Famous Town Halls. In Belgium and Holland French ideas were adopted at an early period, and the splendid cathedrals of Antwerp, Tournai, and Brussels show to what extent these ideas were absorbed. But the genius of the race found its peculiar expression in secular architecture, as was only natural with this prosperous state of traders, with their highly developed civic institutions and guild system. The main features of the town halls are borrowed from ecclesiastic architecture, and even the church steeple finds its counterpart in the lofty belfry rising from the centre of the buildings. At the same time, the secular character and purpose of the civic building are never lost sight of, and these edifices are admirably adapted to public business. The town halls of Bruges, Brussels, Ghent, and Louvain are among the glories of Gothic architecture.

Italian Gothic Churches. The local conditions of Italy did not allow Gothic architecture to develop on parallel lines with

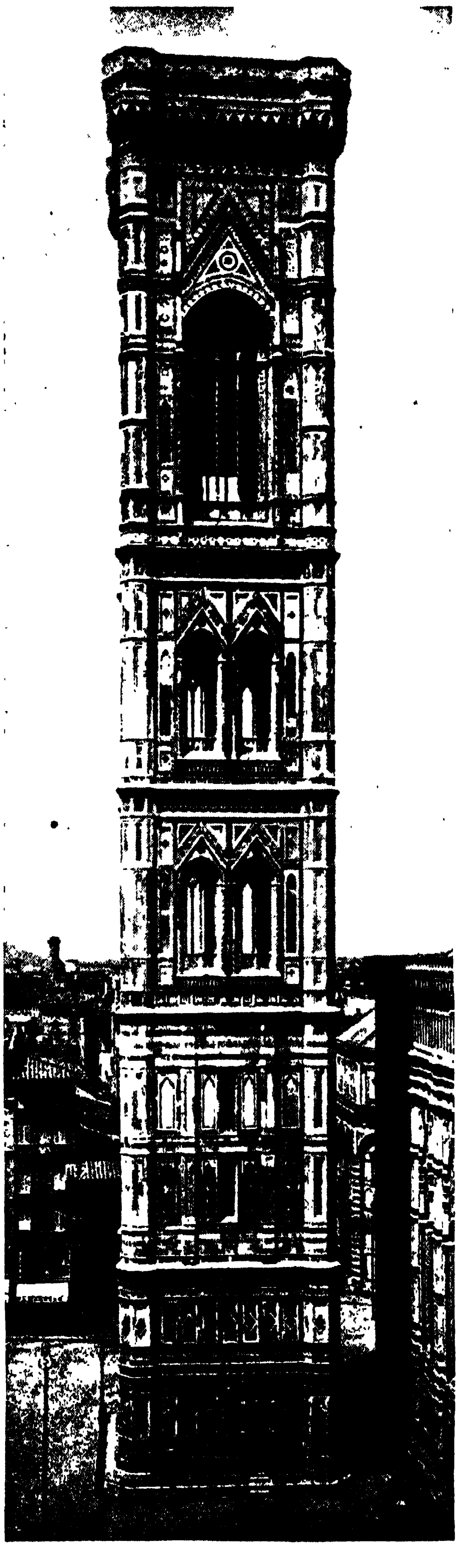
ANTWERP CATHEDRAL

the North; and though the pointed arch was extensively adopted, the full system, based on it, did not find favour south of the Alps, except in isolated cases like Milan Cathedral- the work, to a large extent, of German builders; and even here the absence of a lofty tower and the form of the façade are marked departures from the Northern prototypes.

The abundance of such precious and effective building material as coloured marble, with its possibilities of use or incrustation, the hot climate, which imperiously demands solid walls with small windows for protection against the sun, and, above all, the classic tradition which was never quite eradicated, even when it was overshadowed by foreign influences—all these factors left their mark on Italian Gothic churches, which retained more or less the horizontal tendency and the preponderance of solid masonry, decorated with stripes and panels of marble inlay, over openings.

Moreover, the genius of the people could not dispense with large surfaces for pictorial decoration, and fresco and mosaic painting had practically ceased to exist in the North as a result of the masonry being reduced to a minimum, a mere frame for the stained-glass work which had usurped the place of painting.

Climatic reasons, again, did away with the necessity for steep roofs. The aisle roofs of Italian Gothic churches are generally masked by the screen-like west front wall, the porch of which frequently projects, with columns resting on the backs of lions; and the dome is developed to such grand proportions as the glorious cupola of St. Maria del Fiore in Florence.



GIOTTO'S TOWER, FLORENCE

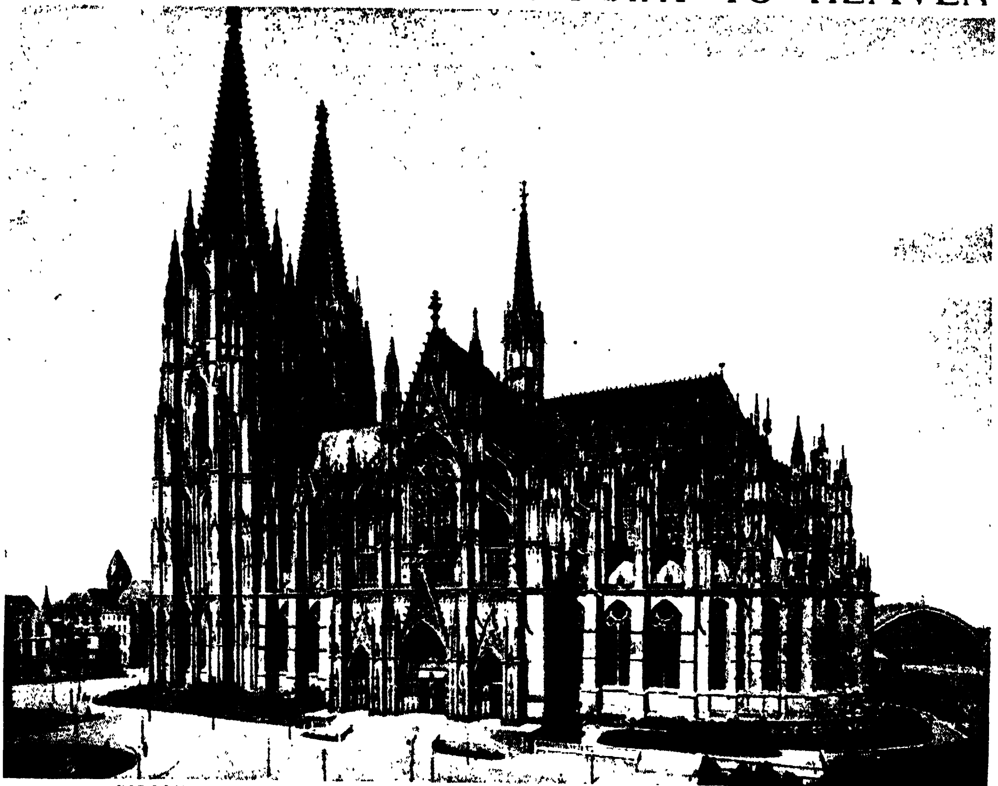
The exquisite campanile of Florence, Ruskin's "Shepherd's Tower," is the perfect result of the blending of Gothic and local character. In Lombardy, where brick frequently took the place of stone as building material, the church of the Certosa di Pavia stands as a noble example of Italian Gothic, while of other churches may be mentioned St. Maria Novella in Florence, and the cathedral of Siena.

In secular architecture we have to distinguish between the massive, defiant, powerful Gothic palaces in Florence, such as the Palazzo Vecchio and the Bargello, and the playful treatment of Gothic motifs in Venice, which found its supreme expression in the Palazzo Cà d'Oro on the Grand Canal. In the Doge's palace the style attains to rare dignity, whilst the two colonnades by which it is adorned stand unrivalled for magnificence. The brick palaces of Siena are distinguished for their noble architectural articulation; witness the Palazzo Pubblico and the Palazzo Buonsignori. But, in spite of the temporary victory of an art ideal which had been more or less imposed upon the Italians by Northern conquerors, the Gothic style always remains alien to the spirit of the race, and only a slight impetus was needed in the early part of the fifteenth century to secure a lasting triumph to the rediscovered principles of antique architecture. The dawn of the Renaissance signified the death of the Gothic style in Italy.

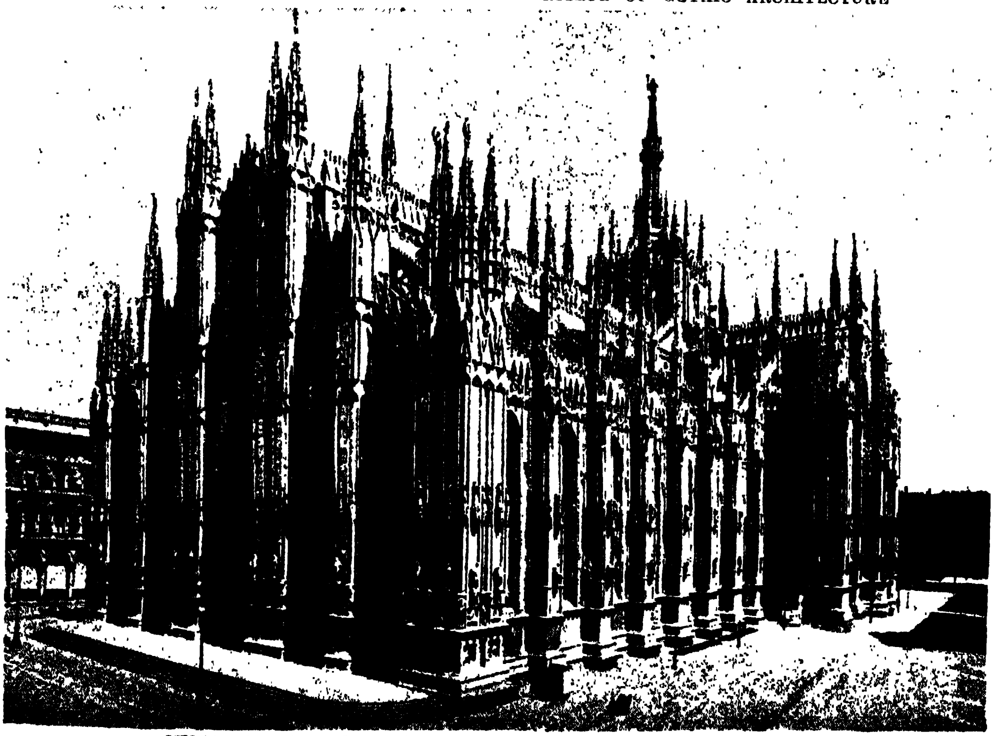
Spain derived her Gothic style chiefly from France, but the cross is frequently crowned by a dome, and rich Moorish ornaments are employed together with Gothic motifs.

P. G. KONODY.

SPIRES WHOSE FINGERS POINT TO HEAVEN



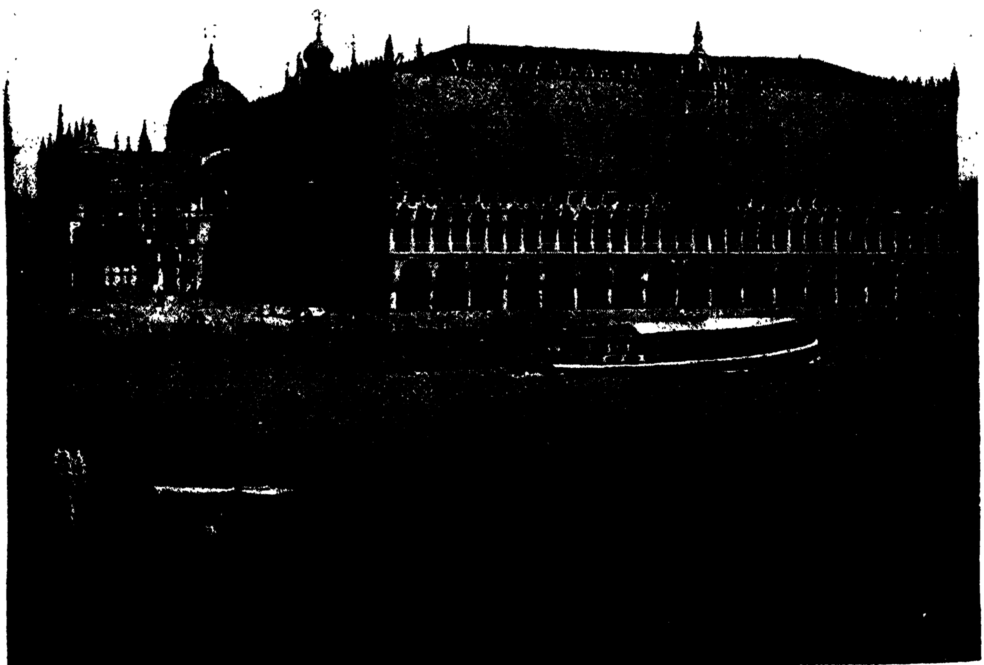
COLOGNE CATHEDRAL—A GERMAN MASTERPIECE OF GOTHIC ARCHITECTURE



MILAN CATHEDRAL—A MARBLE MONUMENT OF NORTHERN ITALY

CIVIC GRANDEUR CARVED IN STONE

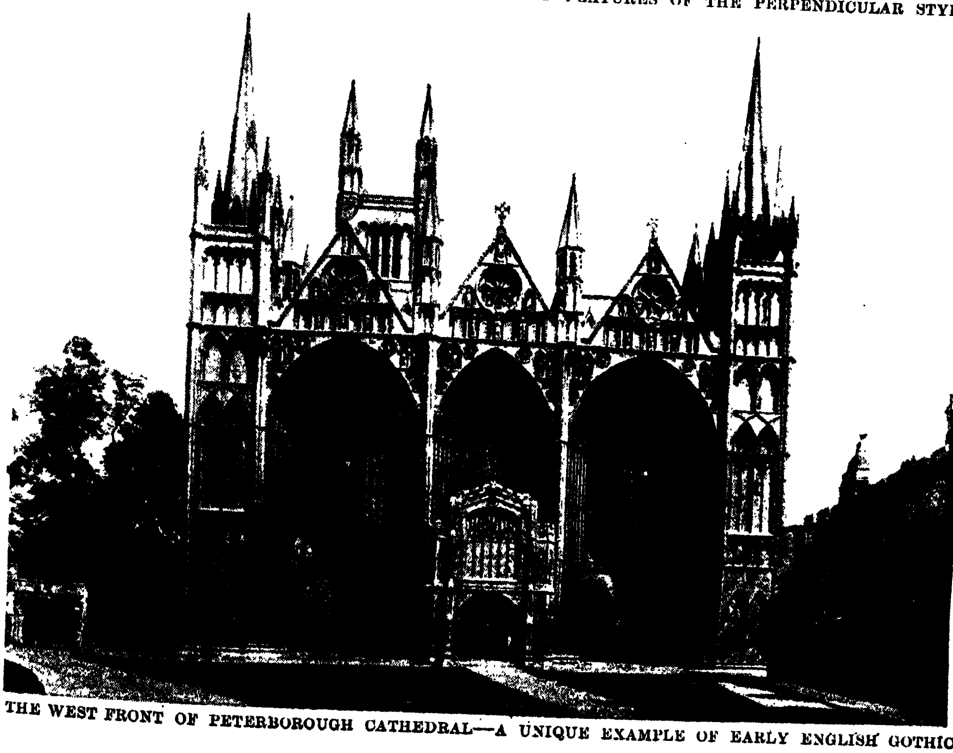
THE BEAUTIFUL FOURTEENTH CENTURY TOWN HALL OF BRUGES



THE TWELFTH CENTURY PALACE OF THE DOGE OF VENICE

TWO STYLES OF GOTHIC ARCHITECTURE

GLOUCESTER CATHEDRAL, WHICH SHOWS PROMINENT FEATURES OF THE PERPENDICULAR STYLE



THE WEST FRONT OF PETERBOROUGH CATHEDRAL—A UNIQUE EXAMPLE OF EARLY ENGLISH GOTHIC

THE MOST PERFECT ENGLISH CATHEDRAL

SALISBURY CATHEDRAL—AN EARLY ENGLISH BUILDING WITH A DECORATED SPIRE, 400 FEET HIGH

THE NAVE AND CHOIR OF SALISBURY CATHEDRAL—A MASTERPIECE OF THE THIRTEENTH CENTURY

The Nose, Lungs, and Thorax. The Process of Breathing. Inspired and Expired Air. Arterial Blood.

THE ORGANS OF RESPIRATION

The respiratory organs include the nose, mouth, larynx, windpipe, lungs, and pleura, with the nerves and blood-vessels belonging to them.

The Nose. We are aware that the nose is not generally included in this category, and the omission has led to serious results. The sense of smell has been considered the sole function of the nose, but breathing is undoubtedly the primary function of the nose, and all inspired air should pass through it. Indeed, it is because it is so designed that the olfactory organ is situated in the upper part to catch the odours the air may carry—a useless position if all the air is intended to enter through the mouth. The mouth, however, serves for expiration equally well with the nose. Air breathed in through the mouth is raw, cold, laden with germs and the filthy dust of streets and rooms, thus drying the tongue, destroying the teeth, causing sore throats and snoring, and clogging and poisoning the lungs.

Air breathed through the nose is warmed, moistened, and cleaned so perfectly from all germs and filth that not one microbe passes down into the lungs.

The nose, therefore, is the first respiratory organ. Its passages are tortuous, and yet free, lined with stiff hairs to intercept foreign bodies, and with ciliated epithelium, that catches all the dust. An abundant blood supply keeps its passages warm, while a free secretion of mucus keeps the air moist. The posterior nostrils are twice the size of the anterior, and through them the air passes behind the soft palate down the larynx. The vocal cords, in a quiescent state, afford a free and silent passage for the air to pass to and fro in breathing; and it is only when used for vocalisation that the passage of the air is obstructed.

The top of the larynx can be closed tightly by a lid called the epiglottis, but it is never closed save just in the act of swallowing, when it shuts down as the tongue is carried backward.

How Air passes down to the Lungs. The air, then, enters by the nostrils (we can see how they act if we watch a horse breathing), and passes backward through the posterior nares (nostrils) into the throat, and then down through the epiglottis, which is open, into the larynx, or voice box. The air, passing through the larynx, then enters the windpipe, which is called the trachea, because it feels rough outside on account of the 16 to 20 rings of gristle that surround it. This pipe is an inch in diameter, and 4½ in. long. Just behind the breastbone it divides into the right bronchus (almost horizontal) and the left bronchus (almost vertical). Each *bronchus* runs into a lung—the two bronchi and the two lungs looking just like two huge sponges growing on two stout branches, the bronchi forming stalks to the lungs [**42**].

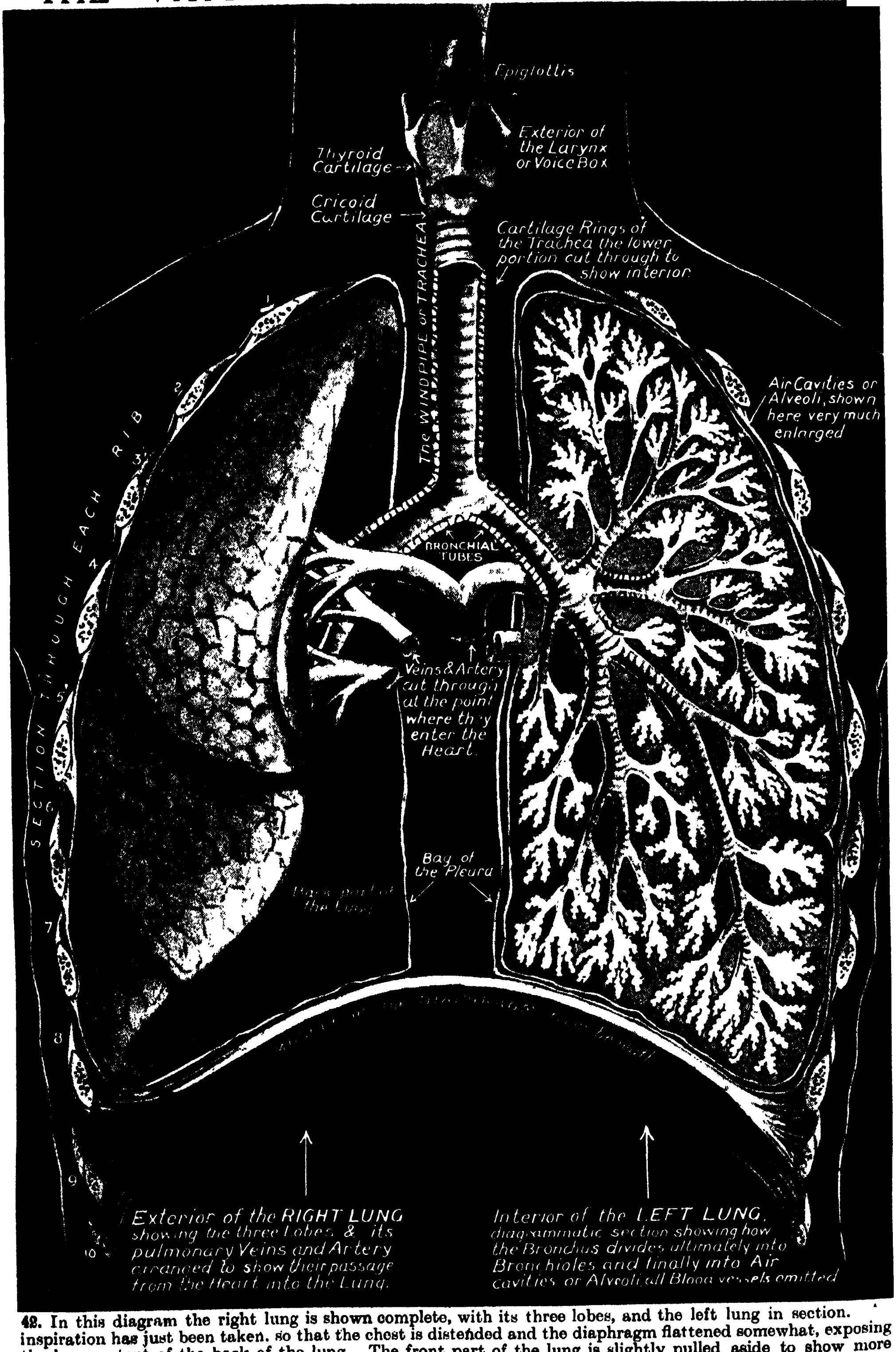
The right lung, having a weight of 23 oz., is in three lobes, and the left, weighing 19 oz., is in two lobes. When the bronchi enter the lungs they rapidly divide and subdivide, exactly like the branches of a tree, until at last the twigs get very small (only one-fortieth of an inch in diameter). Each tiny twig then ends in an air-cell one-fiftieth of an inch in diameter, somewhat the shape of a grape, only the outside is *not smooth*, but like a raspberry or blackberry [**43**].

A bunch of these cells fixed on the little air-twigs looks very like a bunch of grapes. When the air gets as far as this, its further progress is stopped. The outer sides of these air-cells are covered with such myriads of blood-capillaries that it is said that if those in the lungs alone were stretched out in one straight line they would reach from here to America.

The Purification of the Blood. These capillaries differ from those in the body, for those brought food to the cells and took away the refuse; they gave up all the fresh air from the corpuscles to the body-cells, and took away carbonic acid gas. These bring the bad air and take away the fresh. The red corpuscles that arrive here laden with carbonic acid gas, and of a dark colour, thus have them filled again with oxygen, and changed to a bright red colour. The walls of the capillaries and of the air-cells are so thin that the oxygen from the air can easily pass through the cells into the blood, and the carbonic acid in the blood can easily pass out of the blood into the air. The surface of blood that is exposed to the air [**46**] at each breath in the thin film in the capillaries outside the air-cells is equal to about fifty-six square yards. All animals inspire oxygen and give out carbonic acid gas; and in all there are lungs, or the principle of a lung, which consists essentially of a thin membrane with air on one side, and blood in small thin vessels on the other.

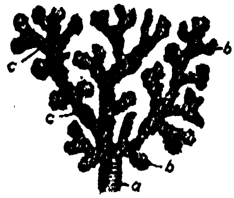
The blood, thus purified, then returns by the four pulmonary veins to the left auricle of the heart. Both the bronchi, the bronchial tubes, and the windpipe are lined with *ciliated epithelium*, the hairs of which are always waving upward toward the throat, and so pass up any grains of dust that may be breathed in.

These bunches of air-cells are all matted together by fibrous tissue, blood-vessels, and nerves, into the spongy substance we call lung.



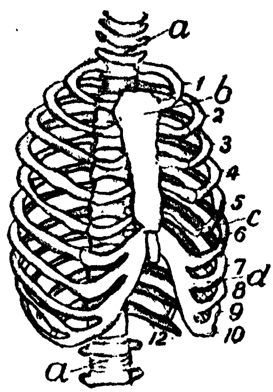
48. In this diagram the right lung is shown complete, with its three lobes, and the left lung in section. inspiration has just been taken, so that the chest is distended and the diaphragm flattened somewhat, exposing the large extent of the back of the lung. The front part of the lung is slightly pulled aside to show more clearly the entrance of the artery and the exit of the veins which carry the blood to and from the lungs.

The Pleura and Thorax. Covering each lung with the double folds of an empty bag, after the fashion of the pericardium round the heart, already described, is the pleura. right and left. The outer layer of the bag (the parietal layer) adheres to the inner side of the thorax or chest wall, lining it with a smooth and glistening membrane. The inner layer (the visceral) is equally adherent to the lung, which lies close against the chest wall. Between the two layers is a little fluid that lubricates the two surfaces and enables the one to glide upon the other in the incessant movements of respiration, without friction and without noise, thus performing the function of a universal joint.



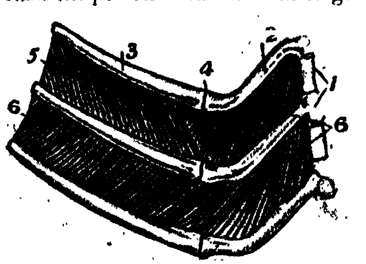
43. THE TERMINAL AIR CELLS OF THE LUNG
a. Small air-tube. *b*. Terminal air-cells. *c*. Smaller air-tube.

So much, then, for the structure of the respiratory organs. The thorax itself, which is filled by the heart and lungs and large vessels, consists of a dome-shaped cavity [**44**], closed in at the top by the ribs and fleshy part, the only opening into the lungs being through the windpipe. Its back is formed by the spinal column, its movable sides by the ribs, which are each jointed behind to the backbone, and the upper seven pair in front to the breastbone. The next three are each joined by cartilage to the pair above them, while the last two are free in front. The lungs are thus shallow in front (down to the 6th ribs), and deep behind (down to the 11th). The floor of the thorax is formed by a strong muscle (the diaphragm) stretching right across the body, slanting downward behind, through which the blood-vessels and gullet pass.



44. THE BONES ENCLOSING THE THORAX
a. Vertebral column: 1-12 Ribs. *b*. Sternum. *c*. Costal cartilages. *d*. United cartilages of upper false ribs. 11 and 12. Floating ribs.

We will now proceed to consider the mechanism, muscular and nervous, of respiration. The force expended in opening the chest in inspiration each day is enough to raise the person the height of St. Paul's, and is thus only about one-sixth of the force spent in the circulation. Breathing consists of two acts—*inspiration* and *expiration*. *Inspiration* is a *forced muscular effort* performed by *three* distinct sets of muscles—those that act on the ribs, those that act between the ribs, and the diaphragm, which is the floor of the thorax.



45. THE INTERCOSTAL MUSCLES
1. Sternum. 2. Cartilages. 3. Ribs. 4. Junction of ribs with cartilages. 5. External intercostal muscles, laid bare on the left in 6.

In inspiration *the chest cavity* is made broader, longer, and deeper. When at rest, the ribs, hinged behind to the backbone and in front to the breastbone, hang down like the iron handle on the side of a bucket. Now, if we raise such a handle, it not only moves upward, but outward. The same takes place with the ribs; and, in addition, the sternum, or breastbone, being movable, rises forward as well, and thus the chest is made *broader* and *deeper*. It is made *longer* because, when at rest, the diaphragm muscle forms an arched floor, that rises like a dome into the thorax, and on which the lungs rest. As this muscle contracts it flattens the floor, pulls the lungs down, and as a result makes them longer from top to bottom.

The muscles that raise the ribs are in two sets—those that act on the ribs and those that act between them. The upper ribs are pulled upward by the action of muscles passing down from the neck.

Between each rib is a double layer of muscles crossed like an x; they are called the intercostal muscles, because they are between the ribs [**45**]. The top ribs being fixed as these contract, they tend to raise the lower rib, to which they are attached; and thus, by acting together, all the ribs are elevated.

This constitutes the movement of inspiration.

In expiration, *the chest returns to its original size* without effort. This is mainly caused by *elastic recoil*. The lungs are full of elastic tissue, which is stretched when the lungs are expanded; and, as soon as the muscular effort ceases, the elastic force is so great that the lungs pull the ribs down again, and pull up the floor of the diaphragm [**47**].

When we draw in a breath the abdomen swells out. This is caused by the contraction of the diaphragm, which presses all the digestive organs down and makes them bulge out the walls. In expiration the abdomen gets flat again, as the floor rises once more.

The force required to stretch out the elastic tissue in ordinary inspiration is equal to 170 lb.; and the total daily force used in respiration is 21 foot-tons.

The nervous mechanism of respiration is of great practical interest. There are two great centres in the brain where respiration is controlled—the one is the conscious region, under the control of the will, and hence, of course, voluntary: the other is the unconscious region, which is involuntary, and governed in its action by the unconscious mind. The movement of the muscles is controlled from

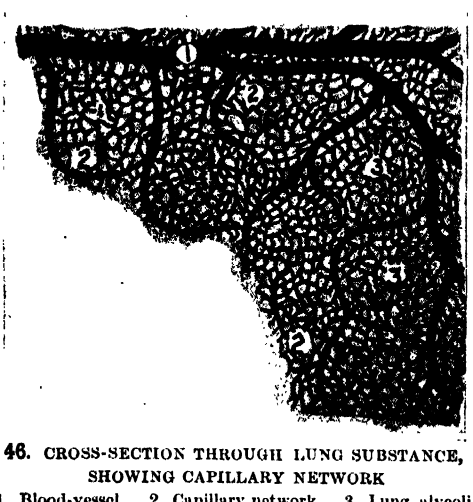
those centres by various nerves, notably the pneumo-gastric nerve.

Practically our breathing is under our own control up to the point where life is involved. We can breathe in any manner and at any rate we please. Were it not so, speaking would become impossible. We can also hold our breath up to a certain point; but when life is beginning to be threatened the other involuntary centre comes into play, and, in spite of the strongest effort of will, forces us to breathe. This control also acts continuously when we are not thinking of our breath at all. None of the vital processes require our constant attention; yet with some we are allowed to play up to the point of danger, but no farther.

It has been observed that the sexes breathe differently, and it has been thought, and laid down in text-books, that the difference is a part of the many distinctions observable between men and women.

Children of both sexes up to puberty were observed to use all their ribs in expansion, and the diaphragm by descending in inspiration. But from this age the types began to diverge. Girls and women breathed increasingly with ribs only, the diaphragm remaining stationary, and very many women with the upper six pairs of ribs only. Men, on the other hand, tended to breathe less with their ribs, and more by descent of the diaphragm.

It is now discovered that this variation is chiefly due to the difference of dress. Diaphragmatic breathing involves a change of two or three

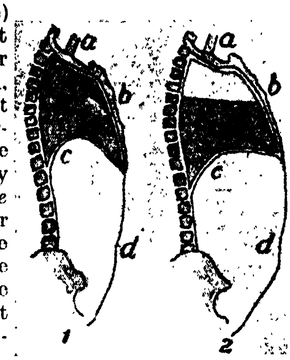


46. CROSS-SECTION THROUGH LUNG SUBSTANCE, SHOWING CAPILLARY NETWORK

1 Blood-vessel. 2. Capillary network. 3. Lung alveoli or air-cells.

inches in the circumference of the waist, and when this is enclosed in a rigid dress-band somewhat smaller than the least waist size (to say nothing of corsets), it is evident that movement of the diaphragm becomes impossible. If the corsets be at all rigid, the lower ribs also become fixed, and the whole strain of respiration is then thrown on the upper half and most delicate part of the lungs, the place, indeed, where consumption almost invariably begins; while the stationary lower half is a favourite seat of congestion.

We must now consider the air that is respired. We only take our solid and liquid meals three or four times a day; our air-meals, or breath, we have to take 17 times a minute! The air we breathe (if pure) consists of one part of oxygen and four parts of nitrogen, with just the least trace only of carbonic acid gas. The nitrogen is only used to *dilute the oxygen*, as water is used to dilute brandy, for the oxygen would be too fiery without it. Oxygen supports combustion, and enables all substances to burn, but will not burn itself. The heat of the body is kept up entirely by a process of slow combustion. Rapid combustion produces a *flame*, as when gas burns in the air; slow combustion produces *smouldering*, as in the end of a match or cigar, or a red-hot poker. But there is a slower combustion that only produces *heat*, as when a little sulphuric acid (oil of vitriol) is poured into a glass of water. There is no flame or burning, but the water gets quite warm. This is the sort of combustion that takes place in the body.



47. THE AIR IN THE LUNGS

Showing the form of the sternum, diaphragm and abdominal wall in (1) Expiration, (2) Inspiration. *a*. Trachea. *b*. Sternum. *c*. Diaphragm. *d*. Abdominal wall. The shaded portion represents the stationary air.

Good Air. It is of the utmost importance that the air we breathe should be pure. The food we take has often to be brought great distances to get it good and pure, but we are always obliged to breathe the air that is close around us; so we should never live or sleep in close, impure, unventilated rooms. If we do, we cannot be healthy, for we cannot get pure air.

If we breathe the air in a room where a number of people are crowded together, it is not only full of *poisonous carbonic acid gas* from their breath, but full of *decaying particles of animal matter* given off from the skin and lungs of so many people.

The air we inspire, as a rule, is fairly *dry*, *cool*, or *cold*; is full of *dust*, and other particles, and is composed of *one part of oxygen and four parts of nitrogen*. The air is drawn into the lungs by their being stretched out and made so much larger by muscular effort that a vacuum is produced, and the air rushes in to fill the space.

The amount of air taken in at an ordinary breath is 20-30 cubic inches. This is called *tidal air*, for it goes in and out like the tide. If we take a very deep breath, we can draw in 100 cubic inches more, which is called *extra* or *complemental air*. Now, when we have expired this, and the tidal air, if we breathe out very hard we can expire another 100 cubic inches of

air, called ***reserved air***, and then, when the last particle of air has been breathed out, there still remain, far down in the air-cells, 100 cubic inches of fixed or *residual air* that never leaves the lungs. We can easily understand that if the lungs hold ordinarily 230 cubic inches of air, and can be made to hold 330, the 30 we breathe in and out only just moves the air in the larger tubes, and never reaches the air-cells at all.

The wonder, then, is how the fresh oxygen ever gets to the blood if the air-cells and smaller tubes are always filled, as the depths of the ocean are with water, with an air that never moves. This is due to the law of diffusion of gases, by which any two different gases brought together at once mix.

When we draw a breath in, charged with pure oxygen, the carbonic acid in the fixed air in the air-cells at once diffuses out into the pure air, and the oxygen of the pure air at once diffuses into the impure air in the air-cells. Were it not for this law, fresh air would never reach the blood at all. We quite understand that carbonic acid gas is not made in the lungs, but all over the body, and all that takes place in the lungs is its exchange for oxygen.

Expired Air. Expired air differs in every way from inspired air. The analysis of the two is as follows:

Inspired Air		Expired Air	
		Ammonia & org. salts	·4
CO_2	·04	CO_2	4·1
N	79·15	N	79·5
O	20·81	O	16
	100·0		100·0

In short, four parts of oxygen are replaced by four of CO_2.

Expired air is *hot*, about blood-heat, *full of water*, contains *no dust*, a little *decaying animal matter*, a considerable amount of *carbonic acid gas, and a diminished amount of oxygen.*

We can prove this by experiments:

1. *To show it is hot.* We breathe on the bulb of a thermometer, and we shall see it rise to about blood-heat.

2. *To show it is full of water.* If we breathe on a cold looking-glass, or the blade of a steel knife, we shall see it soon covered with drops of water. When the air is cold, we can actually see the water vapour coming out of our mouths.

3. *To show it contains carbonic gas.* If we breathe through a piece of tube into lime water it will soon become milky, owing to the forming of chalk, which is carbonate of lime, and is made by the carbonic acid of the breath uniting with the lime in the water.

About half a pint of water and half a pound of solid carbon pass out by expiration each day, as well as a great deal of body heat. These amounts increase during life from 1 to 30, remain stationary from 30 to 50, then slowly decrease. The CO_2 expired varies in proportion to the amount of muscle waste from work done. With quick breathing, rise of temperature, and in the autumn, the CO_2 is less. In the spring and under opposite conditions, it is more. Of 100 parts of CO_2 daily expired, 52 parts are expired in 12 hours during the day, and 48 in 12 hours at night.

How Arterial Blood is Made. We must now describe the changes effected in the blood by respiration.

The venous blood, laden also with organic refuse from the tissues and from the lymphatics, arrives at the lungs through the pulmonary artery from the right heart, and is spread out in the finest capillaries on the outside of all the air-cells. There, by diffusion, a little over 4 per per cent. of CO_2 is introduced into the air, together with about ·4 per cent. of effete animal matter and ammonia out of the blood, while to keep the balance, a corresponding amount of O is introduced with the blood, with the effect of at once making it bright scarlet.

The following experiments will illustrate the way in which the change between the two gases takes place in the lungs:

1. If blood is allowed to run from a vein, and form a clot in a plate or saucer, the outside of it will be seen to become bright red, because the carbonic acid passes into the air, and the oxygen takes its place. But underneath, or inside, it remains quite dark, and if we suddenly turn it over we see this, though the dark part soon becomes bright when exposed to the air.

2. If we get a little bright blood in a moist bladder and hang it in a jar of carbonic acid gas, it gets purple. If we now hang it in the air in a jar of oxygen, it gets bright red again, showing that the gases can pass through the walls of the bladder as they pass through the air-cell membrane. Such, then, is the normal process of respiration, but various abnormal processes, such as *asphyxia*, occur.

The Control of Sound by the Larynx. Ordinary expiration is quite quiet, because the larynx is kept widely open, and the two bands known as the vocal cords are far apart. If they are brought together, however, some sort of sound is made in expiration. Talking and singing, groaning, laughing, coughing, all take place in this way. Sound is only formed in the larynx, words are made in the mouth. In laughing the breath comes out in a series of explosions; coughing is very similar.

Sighing and gaping are two special forms of inspiration we will explain here. If from any cause insufficient oxygen is getting into the blood, as, for instance, when a boy is sitting writing or studying, and breathing very gently for a long time, the nerve-centre that controls the breathing sends an impulse to fill the lungs with fresh air, and he heaves a sigh, which is thus an effort of Nature to get enough oxygen. Panting is an effort made for the same reason. Yawning is a still more determined effort. Hiccough, coughing, sneezing, sniffling, sobbing, laughing, sucking, are examples of various forms of inspiration and expiration of special character and for other purposes than ordinary respiration.

A. T. SCHOFIELD

Methods of Cutting Cereals. Building the Rick. Threshing. Mangel Clamps. Hiring and Wages.

HARVESTING THE CROPS

The harvesting of the crops of the farm is, perhaps, the most important feature of the agricultural year. If it is essential to cultivate the land with thoroughness and to sow good seed under the best conditions, it is still more important to save the crops which have been produced by the adoption of those necessary forms of labour. The harvesting of the grain and pulse crops is conducted under very different conditions to those which obtained 50 or even 25 years ago. Hand labour has been largely supplemented, or replaced, by machinery, and it has long been obvious to all concerned that but for machinery the cost involved would have been much more serious, with the result that the farmer's occupation would have become a most precarious one. The date of harvest varies—even in this small country—owing to the differences in climate, soil, and temperature. Sometimes, indeed, corn is cut in the South by the third week in July, while we have seen the reaper at work in the North about the middle of September, and in exceptional years, chiefly owing to adverse weather, corn crops have remained in the field until November.

The Right Time to Cut. Experience is of great value in enabling the farmer to decide when to begin to cut his crops. While he is seldom likely to cut too early, it teaches him that he may cut too late, with the result that the grain is either shed or partially spoiled. To wait until wheat or oats are actually ripe is fatal. Wheat, for example, should be cut when the straw has begun to turn from green to yellow just below the ear, but it must be dry. Difficulty, however, often arises when a large area of grain ripens simultaneously, and when, in consequence, though the farm is well equipped with machinery and men, some must be left.

The Passing of Hand Labour. In days now happily passed away, the sickle or the scythe were the only tools employable, the latter especially involving considerable physical labour, from half an acre of wheat to 1¼ acres of barley being cut in an average day. The area mown, however, depended to some extent upon whether grass or weeds were grown with the corn. A smaller area was cut with the sickle, which, like the scythe, is now occasionally used—although there are but few men who can do a good day's work with the latter where the corn has been beaten down or twisted by the wind or rain. Hand tools were succeeded by the reaping machine, and the reaper by the self-binder, which, without stoppages or breakages, and with sufficient horse-power, will cut an acre in an hour, or an average of eight acres in a day, the machinery being kept well oiled and exchange knives kept sharp by an assistant.

The Advantages of a Binder. The reaper—which cuts the corn, and, by the aid of the sails which revolve over its platform, deposits on the ground, at equal distances apart, sufficient quantities for tying into sheaves—although a useful machine, is much inferior to the binder. It involves the employment of hands for making bands and tying the corn, whereas the binder ties every sheaf with twine and deposits it ready for stooking. As the corn is cut by the binder it is elevated and packed until sufficient for a sheaf is collected. It is then released, encircled, and tied with twine, which is then cut, the sheaf being simultaneously thrown out.

On a well-conducted farm the whole harvest tackle should be overhauled and prepared for work before harvesting begins. The reaper, or binder, should be in perfect condition, twine purchased, and such spare parts as may be needed owing to wear and breakage procured from the manufacturer; and this especially applies to knife sections, fingers, bolts, rivets, and the cloths which are used for elevating corn on so many machines. The horses should be reliable, and sufficient in number to admit of changes for rest. Judgment is needed, too, in the manner of cutting, for the crop must stand against the machine. If bent, laid, or twisted, the result may be that it is cut too high, leaving much straw on the ground, or that the ears are cut off and wasted, owing to the fact that they cannot be collected with the horse-rake.

Building Stooks. As the sheaves are deposited, they are set up into stooks, four to six a side, wide apart at the bottom, and sloping toward the top, so that the ears of opposing sheaves are close together. In this way damage by rain is minimised. It is important, too, that the stooks should be set in the right position, that the wind may pass through them, and thus assist in drying them for carting. Where stooks are carefully built, they will sustain a good deal of rain without harm, but if thoroughly wet, the sheaves may be laid out for drying in the sun. It is sometimes necessary where weeds are plentiful, or where grass or clover sown with the corn has grown with freedom, to untie the sheaves after heavy rain that they may be thoroughly dried before carrying, as wet sheaves in the rick heat, and spoil both corn and straw.

Such operations are occasionally necessary from time to time, and thus it is that wet weather involves an expensive harvest. Great judgment is required before carrying, especially in changeable weather. The time, however, may usually be determined if the farmer goes in advance of his waggons, and personally examines the sheaves by thrusting his hands into

the centre beneath the band. Whether carts or waggons are employed is a matter for private decision, although it is usually governed by local custom. The number of waggons and hands employed in carting depend upon the distance of the field from the stack.

Oats. Oats, like wheat, are cut when the straw assumes a yellow tint. On no account must they be left to ripen, for the crop becomes a prey to birds, and quantities of grain are shed. Oats are usually spoiled if they are stacked in a damp condition. How far the damage has proceeded is too well realised when the grain from a crop which was carried damp is employed for seed. Dampness is followed by mould, a musty smell, and an unnatural colour. As oats are more liable to damage than wheat, they are usually kept longer in the field.

Barley. Barley, contrary to wheat and oats, should be practically dead ripe, with the ear hanging as though the straw had been fractured at its base, and the grain hard and wrinkled. dried grass may be considerable, for, if heated in the rick, barley is useless to the maltster.

Where a barley crop is clean and dry, and the weather all that can be desired, the binder is sometimes permissible, but the chief advantages are expedition in carting and threshing. It is most essential to stack barley in an absolutely dry condition, leaving nothing to chance, and covering the rick with thatch at the very first opportunity. A small percentage of wet sheaves will always spoil a malting sample; hence, from first to last, damp sheaves should be excluded. In some parts of these islands where the rainfall is heavy, it is customary to build a series of very small ricks rather than a few large ones, to minimise damage by heating and mould.

Beans. Beans are cut with the reaper, the scythe, or the hook, or under certain disadvantageous conditions they are pulled by hand. The bean crop is ready for harvesting when the leaf drops, although the corn is still soft. Owing to the stouter character of the

A MOTOR-DRAWN BINDER CUTTING A CROP OF WHEAT

It is usual to allow a barley crop, when cut, to lie loose on the ground, for in this way it can be carted earlier, while it is sometimes improved in quality if there is sun by day and dew at night. The process of turning the crop while in the swathe is in such a case followed by a more uniform colour and general mellowness. For the reason that tying is seldom essential, and because the straw is shorter and lighter, barley is often cut with the scythe, especially as fewer ears are lost. Barley, too, as a rule, though shorter, stands less erect before the reaper, with the result that the ear is often removed by the knives. Grasses and clover, lucerne and sainfoin, are often sown with a barley crop; hence, especially in wet seasons, a considerable quantity of green material, or it may be of weeds, is present, for which reason tying becomes next to impossible. A high-priced malting sample must be well coloured, and this is largely prevented by tying, while the risk involved in stacking sheaves largely composed of partially

haulm, or straw, beans are often cut in damp weather, tied, stooked, and left in the field until quite fit for carting. When well dried, however, the crop becomes brittle, and unless great care is exercised a proportion of the corn will be shed and lost. Beans require plenty of weathering before stacking, although, if sufficiently dry, they may be successfully carried during damp weather, such as that which would be unsuitable for cereal crops. As bean straw is a valuable fodder, however, it is wise to make every effort to prevent the slightest damage.

Peas. Peas are usually cut with a hook or sickle, and laid in heaps, which are turned two or three times, as may be found necessary, especially if the weather is damp. The pea crop should never remain to ripen before harvesting; the pods become brittle and are liable to open, and, when the pulse is hard, to shed it. Peas must be quite dry before carrying, otherwise they heat and become mouldy, when the very valuable haulm, or straw, is diminished in value

as a food for stock. When the pea crop—both pods and straw—assumes a yellowish colour, it is ready for the sickle.

Building the Rick. In the building of corn ricks, it is most essential that the corn should be protected against vermin. For this reason, staddles from two to three feet off the ground are of great value, especially as they permit the free circulation of air beneath. Where these are not employed, the rick bottom should be made by the aid of faggots, and plenty of them. Where the corn is in sheaves, the centre of the rick should be kept the highest, and the sheaves laid sloping, with the ear ends upward and toward the middle. Then if rain enters the rick, it will be shot off toward the outside, leaving the grain little damaged. Allowance must be made in all cases for settlement before the rick is thatched.

Corn ricks are usually round, with the bottom or butt ends of the sheaves at the outside, so that the corn, being within, cannot be stolen by birds. In building, the diameter of a rick increases from the bottom to the eaves, and diminishes from the eaves to the point at the top, this portion of the roof being covered with extra thatch. Some farmers pare the outsides of the rick from the eaves downward, not only with the object of making it look more tidy and presentable, but of giving it compactness and affording protection. The body of the rick, like the roof, should be even on all sides. The roof in particular must be well finished off before thatching, otherwise, with settlement, hollow places will form, which may admit rain and result in damage. Ricks are usually thatched by the square of 100 ft., at a cost of from 1s. to 1s. 3d. per square, the farmer finding the straw, the stakes, and the twine, where thatching twine is employed.

Threshing. Threshing is more frequently a winter operation, and where a threshing machine does not form part of the equipment of a farm, it is usual to hire it, payment being made either by the hour or day, the bushel or the sack of corn threshed. Custom, however, usually rules this condition. The threshing machine owner provides the driver of the engine, and usually one or two men: but in practice a gang of men, whose services are more or less necessary, in addition to the ordinary labour of the farm, usually follow the machine. These men are paid by time, and supplied with refreshment. The hands required to conduct the operation of threshing, in addition to the driver and feeder, are for carting water for the engine, removing the chaff and cavings (a coarse by-product between the chaff and the straw), cutting the sheaf-string, bagging and carting the corn. Others will be needed on the corn rick and the straw stack, and for attending to the elevator by which the straw is raised, if such is used.

Before the engine arrives, coal must be purchased and deposited in a handy spot. When it has been removed, the refuse, and especially the weed-seeds which have been rejected by the machine, should be burned. In some cases the cavings and chaff are left for salvage until a more convenient day, with the result that both are often spoiled and even destroyed by rain. This involves great waste and loss, for both are useful as food, and no pains should be spared to secure them while sweet and dry.

Market Samples. The corn, which is usually carted to a secure and dry granary, may have to remain for some time until it is sold. In such a case it is usually essential to turn it with a shovel to keep it dry and sweet. Before sampling for market, and especially, too, before delivery, the corn should be dressed by the winnowing machine, which removes all foreign material and any chaff still remaining, together with the imperfect and broken grains, which are likely to spoil the sample. Two or three dressings, in spite of the time involved, may be essential in order to obtain a first-rate market sample.

Before offering a parcel of grain to a purchaser, it is well carefully to fill a bushel measure, strike it clean, and weigh it, in order that the buyer may be informed as to its natural weight. A market sample should be as perfect as possible, but honest, and taken from bulk, for the corn delivered will have to correspond with it. Samples may be offered to responsible corn-dealers or millers, or to merchants in general on the Exchange. As it will be necessary to name a price when an offer is made, the opinions and experience of other growers may be obtained, and especially those who have already effected sales. When a fair price is offered by a responsible buyer, it is well to sell in times like the present, for delay, instead of bringing better prices, is more often accompanied by a fall. The retention of corn, whether in the rick or the granary, involves additional labour and loss by vermin or birds, or both.

Potatoes. Potatoes, still harvested on a small scale by digging with the fork, are usually lifted with a potato plough or a modern harvester, one or two patterns of which both sort and bag the tubers at one operation. The earlier potatoes are harvested when sufficiently large, and when good prices are commanded, but the main crop must not be lifted until the skin is ripe and adheres to the potato without peeling when rubbed. Potatoes, when dug, are usually left on the ground to dry and mellow before bagging. Care must be exercised in sorting the ware (marketable) and the chats (the small), any unmarketable potatoes being kept apart, while those diseased must be entirely excluded.

Potatoes are preserved by clamping in a manner similar to that adopted with mangels and swedes. The bed should be dry and trenched around the outside, the potatoes packed and piled upon clean, sweet straw, heavily covered with the same material, and later on with at least six inches of dry soil.

Where disease is suspected, or actually exists, care must be taken to remove tainted tubers. Some growers sprinkle the sound tubers in such a case with lime, to prevent further extension of the disease, but the practice had better be adopted on a small scale as an experiment, until it is ascertained whether it proves successful.

The potato clamp should be well ventilated and examined two or three times at least during the winter, if the crop is kept so long, so that in case trouble is discovered a sale may be effected.

Mangels. Mangels are harvested before the arrival of frost, which they cannot withstand. They are pulled, and the tops twisted off by hand, cutting being objectionable. The bulbs are left in rows or heaps on the ground to dry, and, where frost is liable to follow, covered with the leaves until they are carted. The leaves are subsequently left on the ground and ploughed into the soil, in which they act as manure. Mangels are preserved in heaps or clamps, and protected by the aid of straw and soil, as we have suggested in the case of potatoes.

Preserving Swedes, Carrots, and Parsnips. When *swedes* are lifted, the tops should be cut off, but not the roots, common as the plan is. Although in the milder districts they are frequently left in the field, and consumed by sheep in early spring, swedes are always liable to be destroyed by heavy frosts. They may be pulled and laid in rows, and covered with a little soil by the plough, or laid in small heaps in the field, and covered with soil with the spade, or, lastly, they may be carted, like mangels, and clamped. Clamps should always be made in well-selected positions, where frost and rain will be least felt. The roots should be well matured and well protected with straw and soil, but it is important that they should be weathered in the field before carting, this plan hardening or toughening the skins. Diseased roots should be rejected.

A *clamp* is triangular in form; its width at the base should not exceed 7 ft., and the bulbs should be piled to a height not exceeding 4 ft. to 5 ft. Occasional openings should be left in the ridge for ventilation, these being filled with straw. In some districts, however, mangels are preserved in heaps of very considerable size near the cattle houses, without regard to width or height; but no plan is more successful than that described.

Carrots are preserved in the same way as swedes, while *parsnips*, which are hardier, may be left in the ground until required, although it is wiser to dig and clamp them in order that the ground may be ploughed for a future crop.

Harvest Labourers. Harvesting in general demands extra labour on the farm. Large numbers of excellent Irish workmen annually leave their homes for England and Scotland to assist in the work, and, like the regularly employed men, obtain a higher rate of pay, which is necessarily demanded at such a period. Payment is made for harvesting either by the month, the week, or the day. The last is applicable only to temporary hands. Sometimes, however, the men are paid by the job, 10s. to 12s. per acre not being uncommon. The terms asked are sometimes regulated by custom, the same price being paid from year to year, at other times by competition. The farmer is guided by the terms prevalent among his neighbours; the men by those which have been made by the labourers on adjoining farms. Liberal payment usually secures reliable men and good work; but no stipulation should be made for the provision of unlimited beer, which frequently causes outbreaks of temper, quarrels, and disputes, not only between master and men, but between the men themselves. It is doubly economical to provide harvest men with coffee, tea, cocoa, liberal supplies of milk, or a drink made by the aid of oatmeal, sugar, and lemon-juice, if they are agreeable to accept it, rather than to supply beer as part of the money bargain.

JAMES LONG

THRESHING WHEAT WITH POWER OBTAINED FROM AN IVEL MOTOR

Elements and their Compounds in Nature. Hydrogen, Sodium and Soda, Potassium and Gunpowder, Calcium.

THE ELEMENTS IN DETAIL

It has been noted that occasionally the elements occur in the native, free, or uncombined state in Nature. We may make a note of some of these cases.

Oxygen and nitrogen occur in abundance in the atmosphere. Free hydrogen also occurs in very minute quantities. It is somewhat more abundant in the neighbourhood of volcanoes. Iron occurs in the free state in certain meteors, as does the element nickel. Carbon occurs in several forms, as coal and charcoal, derived from the bodies of vegetable organisms long dead. It occurs also as minute crystals, very misleadingly called blacklead, and better named *graphite*, because this form of carbon is used in pencils for writing purposes (Greek, *grapho*, I write). Thirdly, carbon occurs in the form of larger crystals, which we call diamonds. Sulphur, like hydrogen, is found free in the neighbourhood of volcanoes; arsenic, antimony, and bismuth occur free in very small quantities in various parts of the world: the very valuable element platinum is found free in tiny particles mixed with the sand of some rivers in Russia and South America. Silver and gold occur free in many parts of the world. Mercury is sometimes found as such in California, and free copper occurs near Lake Superior.

Elements in the Stars. But hitherto we have spoken only of the distribution of the elements on the earth. We must see if these elements occur anywhere else. Are they found in the stars or the sun, and, if so, do they occur in the free state or as compounds? This is one of the most fascinating and important subjects in the whole realm of science, and it will be dealt with in a special chapter at the end of this section. Meanwhile, however, we may briefly note that the elements we know on the earth *are* found, and are found in their free state, in the sun and the stars. In general, we may say that the elements most abundant on the earth are the most abundant in the heavens. A still more remarkable fact is that we are scarcely acquainted with any element in any of the heavenly bodies which is not to be found on the earth. There have been exceptions to this rule, but, perhaps, only temporary ones. For instance, the gas called helium was first discovered in the sun, as its name implies, but it was subsequently found on the earth in the rare mineral cleveite.

Elements found to be Combined. By far the greater mass of all the matter with which we are acquainted consists of compounds of the elements, and we must now learn to recognise these compounds by the names given them by chemists. Of course, their number is almost endless, but here we are concerned merely with the principal ones. The compounds of four elements—chlorine, bromine, iodine, and fluorine—have various names, which we shall see later, but those that occur in Nature are called chlorides, bromides, iodides, and fluorides Of these, the chloride of sodium is common salt, and as the Greek word for salt is *hals*, these four elements are often called the *halogens*—that is, the "*salt-makers*." Hence, their compounds may be recognised under the general term of *halides*. Very common also are certain compounds of oxygen and sulphur, which are called oxides and sulphides. The rule is that the termination *ide* is applied to a compound which contains two elements—as, for instance, sodium chloride ($NaCl$), each molecule of which contains one atom of sodium and one atom of chlorine.

A great many of these compounds are able to combine with each other, forming double compounds, such as the double chloride of magnesium and potassium, or that of magnesium and sodium. Nearly all the salts of sea-water exist in this complex state of loose union.

Acids, Bases, and Salts. We have said that the compounds of oxygen are called oxides, but this term is only applied to one half, so to speak, of the compounds of oxygen—those which we have already called *bases*. A special name is given to the double oxides of hydrogen and the non-metals. These are called acids; for instance, sulphuric acid, H_2SO_4, is a double oxide of hydrogen and sulphur, which is a non-metal. On the other hand, caustic soda, $NaOH$, is a double oxide of hydrogen and a metal. These last we call *hydroxides*. Thus the technical name for soda is *sodium hydroxide*. In the case of the acids, for convenience, we write the hydrogen first in the formula, so as to indicate that they are acids.

Now, when these two kinds of oxides—namely, the acids and the hydroxides—are mixed with one another, there frequently occurs a rearrangement of their elements, which is called a double decomposition. For instance, when sulphuric acid and soda are mixed, the metal of the hydroxide displaces the hydrogen of the acid; thus, instead of H_2SO_4, we get Na_2SO_4; while the displaced hydrogen unites with the oxygen which is left over, to form water. The name given to the double oxide now formed, sodium sulphate, which is a double oxide of a metal and a non-metal, is a *salt*. We have already seen that this term salt is also applied to the halides, such as common salt or sodium chloride.

Preparation of Elements. Given, then, that we have a number of compounds of the elements, and that we wish to obtain the pure elements from them, how are we to

proceed? There are three possible methods of breaking up the compound and obtaining the element desired.

In the first place, we may break up the compound by electricity. This is possible only when the compound can be dissolved or melted, and when it is a substance which conducts electricity. If these conditions are satisfied, we may pass an electric current through the compound, and may obtain the freed elements by this means. The simplest and most important instance of the employment of this method is the passage of an electric current through water, which is decomposed and provides us with free hydrogen and free oxygen. In other words, the electricity splits the water up into two invisible and colourless gases which have not the smallest resemblance to it. This process of passing electricity through a liquid, by means of which the liquid or some substance contained in it undergoes decomposition, is known as electrolysis; it need not further be discussed here, as it is dealt with in ELECTRICITY.

Other elements that may be prepared by means of this method are sodium and potassium, barium, calcium and strontium, copper, silver, gold, and fluorine.

This principle is of very great practical importance, since it is the essential one of electroplating and electrotyping, each of which is separately discussed in the SELF EDUCATOR.

The Action of Heat on Compounds. But, *in the second place,* a compound may also be resolved into its constituent elements by heat. It is believed that when the temperature is sufficiently high, no compounds can exist, but though this method is thus theoretically applicable to all cases, there are not very many instances in which it is of practical use. One or two may be noted. The very useful element sulphur frequently occurs in union with iron, as what is called *iron pyrites.* When this is heated (say, for instance, in a hard glass tube) some of the sulphur is given off, and can be immediately seen, because it produces a yellow coating upon the glass.

The preparation of oxygen by this method is of historic interest. Priestley discovered oxygen, as we saw in our second chapter, by this method. He applied heat to the red oxide of mercury (HgO), and thus decomposed it, driving off free oxygen, which he was able to collect after passing it through water. Very shortly afterwards the Swedish chemist Scheele obtained oxygen by heating another of its compounds, the oxide of manganese, or manganous oxide, having the formula MnO_2.

But by far the most common method of preparing the free elements is, *in the third place,* by displacing them from their compounds by means of their action on another element. The displacing elements usually employed are sodium, which turns out magnesium and aluminium from their compounds with the halogens; hydrogen, which turns out a number of elements, such as iron, tin, lead, arsenic, and the like; and carbon, which is really the most important of all, because, to begin with, it turns out the hydrogen and sodium themselves, and thus enables us to use them for turning out other elements. Carbon also turns out the metallic elements potassium, zinc, tin, lead, phosphorus, arsenic, and bismuth.

The Groups of Elements in Detail. We must now proceed to consider the groups of the elements in detail. The first group we will take consists of hydrogen, sodium, and potassium.

Hydrogen (literally the "water-maker," because it is one of the constituents of water) has been recognised as an element ever since the work of the great Cavendish, already referred to. It occurs on the earth to a small extent in a free state, and to a very large extent as a compound, as we have already noted. It is present in vast quantities in the stars, and the sun is completely surrounded by an atmosphere of hydrogen. Many of the stars are so eminently characterised by the amount of hydrogen they contain that they are generally described as the hydrogen stars. A typical example of such a hydrogen star is the most brilliant star in the whole heavens, Sirius, or the Dog-star.

The preparation of hydrogen is most commonly effected by the action of metals upon acids. We have already seen that an acid always contains hydrogen. Here let us note that the reader must not be confused by carbonic acid, CO_2. This is really an acid without its water—an *anhydride.* Its full formula would be H_2CO_3. (Compare potassium carbonate, K_2CO_3.) We can obtain the hydrogen by itself if we turn it out from the acid by means of a metal which takes its place. The usual substances employed are sulphuric acid (H_2SO_4) and zinc. The reaction is represented by the formula

$$H_2SO_4 + Zn = ZnSO_4 + H_2.$$

When it is desired to obtain hydrogen in much larger quantities the element may be obtained from water by the interaction of red-hot iron and steam or by the action of steam—that is to say, gaseous water—on red-hot coke. The coke, which is carbon, takes the oxygen from the water, leaving the free hydrogen. When prepared by this method the gas is impure, because it is mixed with a certain amount of a compound of carbon and oxygen.

Properties of Hydrogen. Hydrogen is a colourless, odourless, tasteless gas, the lightest of all known substances. It is understood, of course, that the ether of the physicists, not to be confused with ether, the chemical compound, is excepted when we make this statement: of all the known kinds of what the chemist calls matter, hydrogen is the lightest. On this account the weight of this element has been taken as the unit for comparison with the weights of other elements. The weight of hydrogen is less than $\frac{1}{11000}$th that of water, and its density is about ·07 that of air. Hence it may be poured upward from one jar to another. So light is hydrogen that light vessels filled with it will rise in air. The first balloons were filled, not with hydrogen, but merely with hot air. Of course, as soon as the air cooled, the balloons descended; but balloons are now filled with hydrogen, and can float for an indefinite period.

The gas is only very slightly soluble in water, the universal solvent, which is capable of dissolving at least some quantity of nearly all substances. One hundred volumes of water will absorb about two volumes of hydrogen. The gas may be breathed without causing any deleterious effects to human beings or animals, but it is incapable of supporting life, nor will it support combustion.

Liquid and Solid Hydrogen. Until recent years hydrogen had never been converted into a liquid, still less into a solid, but both these feats have been accomplished by Sir James Dewar, the famous professor of chemistry at the Royal Institution, London. Liquid hydrogen presents no striking appearance. It is by far the coldest liquid that can be obtained. When it is rapidly evaporated under certain conditions its temperature is still further reduced, so that a small quantity of frozen hydrogen represents nearly the lowest temperature yet attained by the chemist. It is probably about 260° below the freezing-point of water. This is reckoned on the Centigrade scale, in which the freezing-point of water is zero, so we may say that the temperature of solid hydrogen is about $-260°$ C. The recent ability to liquefy hydrogen has been of great use in the study of low temperature chemistry, because by its means very low temperatures can be conveniently obtained and maintained.

Certain substances such as carbon and many metals have the power of absorbing hydrogen in a very extraordinary fashion. The rare metal palladium, for instance, absorbs about 900 times its own volume of hydrogen. We cannot doubt that this is more than a merely physical action; there must be some sort of chemical combination. The hydrogen taken up in this form by a metal is known as *occluded hydrogen*. When the metal is heated the gas is given off again. Iron, similarly, has the power of occluding hydrogen, and thus the gas is sometimes found in the iron that has reached the earth in meteors or shooting stars.

Hydrogen and the Halogens. Reference has already been made to the group of substances known as the halogens—chlorine, bromine, iodine, and fluorine. Each of these substances unites with hydrogen to form an acid. Of these the most important is hydrochloric acid. (HCl). The most important compound of hydrogen, of course, is water, which is really the oxide of hydrogen (H_2O). When the two gases hydrogen and oxygen are mixed in the form of jets and ignited, they unite, producing a very intense heat. This oxyhydrogen jet is largely used for heating lime, which then becomes luminous, thus producing the brilliant light, used in lanterns, known as limelight.

If we compare a simple acid, such as hydrochloric acid (HCl), with a salt of that acid, such as sodium chloride or common salt ($NaCl$), we see that there is a certain resemblance in chemical behaviour between hydrogen and a metal. In general we may say that an acid differs from a salt in that the hydrogen of the first replaces the metal of the second.

Thus it was for long thought that hydrogen was really a metal, and that if we could obtain it in a solid form it would have metallic characters, but now that hydrogen has been solidified this view has to be abandoned.

Sodium. This exceedingly important element has a very wide distribution in Nature; it is a constituent of common salt, it is a necessary constituent of all or nearly all living tissues, and it occurs in enormous quantities in the form of many other salts found in the soil and in minerals. Finally, it is abundant in the sun and in the stars. Sodium, when heated, yields a brilliant yellow light which is very characteristic. It is so universally present that in practical chemistry there is no little difficulty in getting rid of all traces of it. It is nowhere found free or uncombined on the earth, though, no doubt, it exists in the free state in the sun and stars. The symbol for sodium is Na, and its atomic weight is about 23. This element was discovered by Sir Humphry Davy in 1807. Davy was one of the greatest of English chemists; he invented the safety-lamp and discovered laughing-gas; he was connected with the Royal Institution; and the famous laboratory in Albemarle Street, where Sir James Dewar has made so many great discoveries, is known, after Davy and Michael Faraday, as the Davy-Faraday laboratory.

Davy obtained sodium by passing a very powerful current of electricity through the hydrate of sodium ($NaOH$), previously fused or melted. The metal is now prepared in a different manner, by heating a mixture of carbonate of sodium and charcoal.

Characters of Metallic Sodium. When the metal is obtained, it is found to be of a silver-white colour and very soft, so that it can be readily cut with a knife. It is exceedingly light, and floats on water. It has an intense affinity for oxygen, which it immediately takes from water. Thus, when sodium is thrown on to water decomposition occurs, and evolves free hydrogen, which immediately burns in combination with the oxygen of the air. When sodium is exposed to air, the surface rapidly tarnishes, owing to the formation of a film of oxide of sodium. This oxide of sodium is formed when sodium is thrown upon water, but it also combines with some more of the water that is present, forming the substance known as caustic soda, or sodium hydrate, which has the formula $NaOH$. The equation represented in this decomposition runs as follows: $2H_2O + Na_2 = 2NaOH + H_2$. As the equation indicates, free hydrogen is formed in this reaction. Caustic soda has very powerful alkaline properties. Sticks of solid caustic soda consequently have a very powerful solvent action on the skin, and were formerly used to remove warts. But radium is best for that.

When either the oxide or hydrate of sodium meets with carbonic acid (CO_2) it forms a compound known as carbonate of sodium, which has the formula Na_2CO_3. As this usually occurs, however, in its crystalline form, there is combined with it a quantity of water. Water which thus combines with salts in the formation of

crystals is known to the chemist as water of crystallisation. The number of molecules of water that combine with one molecule of carbonate of sodium is 10, so the formula of the substance in its crystalline form will read Na_2CO_3, 10 H_2O. On exposure to air, however, the water tends to leave the crystals, which break down and fall into powder. This tendency to lose their water of crystallisation is a general characteristic of the salts of sodium. The property is known as efflorescence, the opposite of which is deliquescence—liquefaction due to the taking in of water.

"Washing" and "Baking" Soda. Carbonate of sodium, known to the housewife as 'washing soda," is found in Nature to a small degree in soda lakes, in the water of some geysers, and also in the soil. It used to be obtained in considerable quantities from certain marine plants. These were burnt, their ashes were treated with water, the solution thus obtained was evaporated, and yielded a very impure form of sodium carbonate, or soda, which was known as *barilla*. This was largely used in the making of soap. The process has now, however, fallen almost completely into disuse, because the salt can now be prepared much more satisfactorily by other means. Of these the first is known as the Leblanc process, and the second as the ammonia process.

The bicarbonate of soda, or baking soda, differs from the last in that it contains twice as much carbonic acid in proportion to the sodium. Its formula is $NaHCO_3$. It is a white powder, somewhat less soluble in water than washing soda; it is largely used in medicine, as a non-irritant alkali.

Borax. Several other salts of sodium are important. The borate, for instance, is known as *borax*. Its full chemical name is biborate of sodium, and it occurs in large quantities in Borax Lake, California. It used also to be obtained from lakes in Tibet. It may also be prepared by the union of carbonate of soda and boracic acid. It is used in medicine, in glass-making, as an enamel, and for other technical purposes. It usually occurs in the form of prismatic crystals which, like those of carbonate of soda, have 10 molecules of water of crystallisation.

The nitrate of sodium ($NaNO_3$) is often known as "Chili saltpetre," or sometimes as cubic saltpetre, because its crystals are very nearly cubical. It occurs in the soil in various parts of South America. Like ordinary saltpetre, it is used in making nitric acid.

The silicate of sodium, known as "soluble glass," is soluble in water; it is used for fire-proofing. Sodium phosphate is a constant constituent of the animal body and a necessary ingredient of the diet of man and all animals.

Potassium. Potassium is an important metal, which has many resemblances to sodium. Its symbol is K, and its atomic weight is 39; it was discovered by Davy at the same time as the discovery of sodium, and in the same way—by passing electricity through fused potash. Potassium is abundant in Nature, but, like sodium, is never found in the elemental state. It occurs in all living tissues, and when plants are burnt it remains in the ash, hence the name potash or potashes. It is an important ingredient of sea-water, and occurs abundantly in the form of its nitrate in the soil of certain parts of South America.

Preparation of Potassium. Potassium is now prepared in similar fashion to sodium, by means of the interaction of charcoal and the carbonate of potassium. The charcoal (which is simply carbon) and the carbon in the carbonate unite with the oxygen of the carbonate to form a poisonous gas, *carbonic oxide* (CO), leaving the potassium behind in the form of a gas, which solidifies inside a flattened box of metal that receives it. There is some danger in the manufacture. The decomposition is represented by the formula $K_2CO_3 + C_2 = K_2 + 3CO$. (Potassium carbonate plus charcoal = Potassium plus carbonic oxide).

Thus prepared, the element is found to be a whitish metal which strongly resembles metallic sodium. It floats on water, which it decomposes in a similar fashion to that of sodium. When sufficiently heated—and the same applies to any salt of potassium—it yields an exceedingly beautiful violet colour, which contrasts markedly with the brilliant yellow colour yielded by sodium. Like sodium, potassium forms certain oxides or compounds with oxygen, but these are of no practical importance.

Caustic Potash. Potash is of great importance. It is otherwise known as caustic potash, potassium hydrate, or potassium hydroxide. Its formula is KOH—which may be compared with the formula of water, HOH, usually written for convenience H_2O. When we make this comparison, we see that the difference between potash and water is that one-half of the hydrogen of the latter has been replaced by potassium. A similar statement is true of caustic soda. Potash is formed by the action of potassium on water. It is prepared for practical purposes by a process similar to the Leblanc soda process. The potassium is obtained from potassium chloride, which occurs in enormous quantities at Stassfurt. This yields potassium carbonate, and from the latter, by its interaction with slaked lime (solutions of the two being boiled), there is obtained caustic potash, KOH. This is usually cast in the form of sticks. It is a very powerful caustic, very similar in properties to caustic soda. It has great affinities for water and carbonic acid, and is very largely used as a reagent in chemistry.

As we have seen, the ashes obtained from burnt plants were called potashes. The carbonate of potash, now prepared as we saw in the last paragraph, may still be obtained by burning wood, in places where wood is cheap and abundant. The plant does not manufacture its potassium carbonate, but takes it ready-made from the soil. It is a necessary ingredient of all soils in which plants are to grow, and, if deficient, must be added in the form of a manure. The purer form of potashes, obtained by recrystallising the crude product, was called *pearl-ash*. Carbonate of potassium is largely employed in

chemical research, in various industries, in glass-making, and also in the making of soap. All soft-soaps contain potassium.

Chlorate of Potassium. Closely allied to chloride of potassium, a white, crystalline, easily soluble salt, usually obtained from Stassfurt, is the salt known as the chlorate of potassium, $KClO_3$. It is of considerable importance because of its large superfluity of oxygen, which it is very ready to give up to any substance that will take it. So ready is it that when mixed with sulphur and charcoal it forms an explosive mixture. It is an ingredient of certain kinds of matches, and it is daily used in medicine as a safe and powerful antiseptic, which it is in virtue of its ability to give off nascent oxygen. In simple ulceration of the mouth no other remedy is so valuable as chlorate of potash.

The iodide, KI, and the bromide, KBr, are of no great chemical importance, but they are among the most valuable of all drugs. The sulphate, K_2SO_4, is occasionally used in medicine. The two salts containing chromium—the chromate and bichromate—are also used in dyeing, in chemical research, in photography, and the latter occasionally in medicine. The cyanide, KCN, owes all its properties to the fact that it is practically equivalent to hydrocyanic or prussic acid. It is a whitish salt used in photography, in chemistry, in electroplating, and formerly in medicine. It is a deadly poison.

Saltpetre. The nitrate of potassium, KNO_3, is usually known as nitre, or saltpetre, the latter name being a modern version of the alchemists' name for it, which was *sal petræ*, or *salt of rock*. It occurs in the soil, as already stated, being formed by a highly complicated and interesting process into which bacteria enter. [See BACTERIOLOGY.] These bacteria form nitric acid in the soil by a union between the nitrogen in organic substances derived from the bodies of animals and plants, and the oxygen of the air, the process being known as *nitrification*. The nitric acid combines with the potash salts present in the soil to form potassium nitrate, or saltpetre. Sometimes this method is employed for the preparation of saltpetre, but, as a rule, the salt is prepared by the interaction of potassium chloride and Chili saltpetre, or sodium nitrate.

When strong solutions of the two are heated together, a double decomposition occurs, the potassium and sodium changing places. Common salt, or chloride of sodium, is precipitated or solidified in the solution, while saltpetre remains in it, and can thus be separated. The salt forms clear crystals, usually prismatic. It is very readily soluble in water. At high temperature water will dissolve much more than its own weight of saltpetre.

The salt is still used in medicine, being now very rarely given internally, but often burnt in a saucer, when it yields fumes which may relieve attacks of asthma. It is much used in the making of fireworks and fuses, and also in ordinary chemical processes. It is a most important ingredient of ordinary gunpowder, of which, indeed, it forms about three-fourths.

Gunpowder. Gunpowder is really a mixture of saltpetre, charcoal, and sulphur, all the ingredients being mixed in the form of a granular powder. Nitre has to be used rather than sodium nitrate, for this salt, contrary to the usual rule of sodium salts, has an affinity for water, and thus the powder made with it cannot be kept dry. It is said that gunpowder was invented in the eighth century. The value of the mixture depends upon the fact that when it is fired the saltpetre gives up its oxygen very rapidly to the charcoal and sulphur. The results of the oxidation of these latter are gaseous, and the nitrogen of the saltpetre is also given off in gaseous form. The smoke which is produced serves no practical purpose; it consists of various solid salts, such as sulphide of potassium. Owing to the fact that a very high temperature is produced, the gases which are evolved demand a large amount of space—about 2500 times as much as the space occupied by the powder. It is the sudden and imperative expansion of these gases rapidly produced at such a high temperature that gives gunpowder its explosive property.

Alkaline Earths. The next group of elements which we may discuss consists of *calcium*, *barium*, and *strontium*. In their elemental form these do not occur in Nature, and they can be obtained in this form only with much difficulty. When a powerful electric current is passed through the chlorides of these metals in a melted state they can be obtained, but they are very unstable, having intense affinities both for oxygen and water. If only the first be supplied to them they immediately form oxides, but if water be present they form hydroxides, or hydrates. These three elements are usually known as the *alkaline earths*.

Calcium. Calcium is a very widely diffused element. It is a necessary ingredient of the living body, especially of the bones. It occurs in the sun and stars in considerable quantities. The other forms in which it occurs on the earth will be named when its various salts are discussed. Of these salts the most important is the carbonate, which has the formula $CaCO_3$. It is one of the most widely distributed of all minerals. It occurs in the forms of limestone, marble, chalk, and coral.

Chalk consists of the calcium carbonate remains of the bodies of countless myriads of minute creatures that once lived in the sea. These have left a sort of "shells" behind them. The structure of the shells can often be detected with a microscope. But calcium carbonate also occurs in a very large number of crystalline forms, such as calc-spar, or Iceland spar, also in the mineral known as aragonite, and in many other forms. Crystalline calcium carbonate, when pure, is colourless, but very frequently it contains various impurities, such as salts of iron, which give it various tints.

The term oolite is applied to the form of calcium carbonate which occurs as minute rounded grains which, like chalk, are of organic origin. Sometimes it is known from its appearance as roe-stone. This structure

is so common in a certain level of English rocks that they are known to geologists as the oolites. [See page 357.]

Changes of Rocks. Under certain conditions the carbonate of lime, or calcium, is constantly liable to undergo a very important change, which plays a great part in geology, for it brings about a number of the slow but incessant changes which determine the form of the earth's surface. The process is simple to understand. On the earth are rocks containing carbonate of lime, much of which acts as a sort of cement, holding rocks together. In the air is a quantity of carbonic acid, CO_2. As rain falls it absorbs some of the acid. The rocks are thus constantly exposed to the action of carbonic acid in solution, and this produces a very important change. Carbonate of lime is converted into bicarbonate.

When a salt contains twice the usual amount of the acid constituent—which in this case is carbonic acid—its character may be indicated by using the prefix *bi*, from the Latin *bis*, twice; or it may be described as an acid salt, in order to indicate that it contains a certain amount of acid, which, so to speak, is "to spare." There is this great distinction between the carbonate and the bicarbonate—that, while the first is quite insoluble in water, the second is readily soluble; hence the supporting structure of the rocks is broken down, and they are washed away, as sand or clay, to form what are called alluvial plains. Thus mountain ranges are slowly crumbled away.

Stalactities and Stalagmites. Another important change produced in a similar way consists in the formation of what are called stalactites and stalagmites. The first consist of long crystals of carbonate of lime, which hang down in very striking fashion from the roofs of limestone caves, looking very much like icicles. They occur along the lines where there are cracks or joins in the roof of the cave—that is to say, along the lines where water from above drips through. As the drops fall upon the floor of the cave the process which resulted in the formation of the stalactite continues, and there is built up from the floor a sort of pinnacle which is known as a stalagmite, and which grows up to meet a stalactite growing from above. Often they join, forming pillars of indefinite thickness. Now, how does this process occur?

The water that percolates through the roof of the cave brings with it a quantity of carbonic acid derived from the air, and is thus enabled to dissolve some of the carbonate of lime from the rock through which it passes, with the formation of bicarbonate. But when the drop reaches the surface of the roof of the cave, and begins slowly to evaporate, the extra carbonic acid in the bicarbonate can no longer be retained. In other words the bicarbonate undergoes decomposition, yielding the insoluble carbonate, which is immediately deposited. A similar process occurs when the drop reaches the floor. The action may be represented by the formula

$$Ca(HCO_3)_2 = H_2O + CO_2 + CaCO_3.$$

Attempts have been made to estimate the age of caves by means of the size of the stalactites and stalagmites which they contain, but these are highly unsatisfactory. Needless to say, stalagmites do not occur except when the floor of the cave is sufficiently level.

Hard and Soft Water. The difference between hard and soft water depends entirely upon the fact that the former contains more than a certain quantity of bicarbonate of lime in solution, whereas the soft water contains very little, or none. But two kinds of hardness are distinguished in water, one which depends on the presence of the sulphate of calcium, and is called permanent, while the other depends upon the presence of bicarbonate of calcium, and is called temporary. It is this alone that concerns us here.

The adjectives are applied to indicate the fact that, in the latter case, the hardness can be removed with comparative ease. Perhaps the simplest way of removing it is by boiling the water, which decomposes the bicarbonate exactly according to the equation given above to explain the formation of stalactites. Another way of getting the bicarbonate of lime out of the water is by adding more lime to it. The lime that is to be added is usually known as milk-of-lime; chemically it is called calcium hydroxide, and its formula is $Ca(OH)_2$.

How to Soften Water. This substance is only very slightly soluble in water, but when it is partly dissolved and partly suspended in water it forms the opaque white fluid which is called milk-of-lime. Now, when this is added to water containing the bicarbonate, the milk-of-lime takes from the bicarbonate its extra share of carbonic acid, which it combines with itself to form carbonate of lime, and this same salt is also formed from the bicarbonate when it has lost its extra carbonic acid. If the water is now filtered or is allowed to stand, the insoluble calcium carbonate is disposed of, and so the water is made soft. The following formula represents the decomposition:

$$Ca(HCO_3)_2 = 2CaCO_3 + 2H_2O.$$

(Calcium bicarbonate plus calcium hydrate =Calcium carbonate plus water.)

Calcium carbonate may further be used to illustrate some other simple chemical changes. For instance, if limestone consisting of this salt be raised to a very high temperature, it undergoes a decomposition according to the formula

$$CaCO_3 = CaO + CO_2.$$

The carbonic acid is driven off, and there is left behind the oxide of lime, CaO, or *quicklime.* This quicklime has an exceedingly strong affinity for water. When this thirst is slaked by the addition of water, the oxide of lime is converted into the hydrate, or hydroxide, of lime mentioned above, which is commonly known as *slaked lime.* The difference between these two last substances is typical of the difference between an oxide and a hydrate or hydroxide.

C. W. SALEEBY

CÆSAR COMES HOME FROM THE WARS

THE TRIUMPHAL PROCESSION OF A ROMAN EMPEROR IN THE HALCYON DAYS OF THE EMPIRE
From the painting by F. W. Topham, R.I., by permission of the Corporation of Leicester

The World's Capital City a Splendid Arena for petty Personal Ambition

THE GRANDEUR THAT WAS ROME

TIBERIUS was no longer young when he succeeded to the "Principate," or Empire. He was experienced both as a soldier and as an administrator; he had rendered invaluable service under his stepfather; but a naturally morose and gloomy disposition had been embittered by the harsh treatment he had received from the old emperor.

As a statesman he was opposed to any expansion of dominion beyond the lines of the three rivers, the Rhine, the Danube, and the Euphrates; he himself had had personal experience of the difficulties of campaigning in what is now Germany. He held the Empire with a strong hand, and his legates and procurators knew that they would be called to strict account, regardless of wealth or family connections, if they misconducted themselves seriously. Consequently, for the Empire as a whole, the reign was a prosperous one. His half-nephew, who is known as Germanicus, conducted, somewhat against the wishes of Tiberius, campaigns which were reputed to have been brilliantly successful among the German tribes, though there was little enough to show for them; and the prestige of the Roman arms was maintained.

The picture we have of Tiberius is by Tacitus, who was concerned rather with the affairs of Rome and Italy than with the Empire at large; and in Rome and Italy the reign was almost a nightmare—at least during its later years. Germanicus, who was extremely popular, was recalled from Germany and died while on an Eastern tour, amid strong popular suspicions of poisoning. The harsh and unpopular emperor himself became the object of plots; the city was filled with informers, spies who grew rich by denouncing real or imaginary plotters. It would seem that no man of prominence felt that his life was safe.

Tiberius withdrew to the island of Capri, where he was reputed to be living a life of hideous debauchery. He left as the master of Rome the præfect of the prætorians—that is, the officer commanding the prætorians, or bodyguard, a great body of picked and privileged troops quartered in the neighbourhood of Rome. This man, Sejanus, designed to use his position to seize the imperial purple for himself. The plot was discovered, and with appalling suddenness the favourite was struck down from his high estate and was put to an ignominious death, with all his kin. His name has passed into a proverb. In the twenty-third year of his reign the old emperor was done to death by some of his attendants, and all Rome breathed more freely.

The successor of Tiberius, chosen by the prætorians, was Gaius Cæsar, the son of Germanicus, better known by his nickname Caligula—a pet name for him among the soldiers in his boyhood. Not long after he became emperor, Caligula was seized with a severe illness which unsettled his reason, and his name has become a byword for frantic cruelties and insane imaginings. The grotesque horrors of his rule were ended by his assassination, when the prætorians, more than half in jest, acclaimed as his successor his uncle Claudius, a feeble pedant, not without cleverness, but wholly unversed in public affairs.

Claudius was fifty years old when he was enthroned. He began his reign with good intentions, and gave promise of success, but he was weak and timid, and was always under some sinister influence. Outside Italy the Empire was not, on the whole, badly administered. It was in this reign that the Roman armies invaded Britain, and brought the southern half of the island under the Roman dominion. The frontiers, too, were efficiently guarded.

But at home Claudius fell under the absolute influence of his wife, Messalina, who had a short way of getting rid of personal or political enemies. History and literature have consigned the name of Messalina to eternal infamy, and made it the synonym of profligacy and cruelty in woman. At last her iniquities led to her destruction, and then Claudius took for his second wife the Princess Agrippina, a woman as ambitious and as merciless as Messalina, though not so profligate. Her great object was to secure the succession to her child by a previous marriage. After a

few years she succeeded. Claudius perished, probably as a result of poison, and in A.D. 54 the boy, Nero, became emperor.

The Infamous Nero. For a time government was by regents, one being the poet and philosopher Seneca, but when the boy grew up he proved himself a veritable tiger's cub. There was in his temperament a singular blending of the furious tyrant and the artistic amateur. He loved music; he had a passion for the stage, and even for the arena. It was one of his delights to drive chariots and display his skill in the management of horses before the assembled multitudes in the great Roman amphitheatre. The citizens of Rome had thus the opportunity of seeing their emperor, who belonged to the family of Julius Cæsar, make exhibitions of himself in this unseemly fashion.

His reign was marked by its persecution of the Christians, which he endeavoured to justify by accusing them of having caused a terrific fire in Rome which consumed half the city, while, according to tradition, Nero looked on and played the fiddle. Many of the Christians were, by his orders, wrapped up in the skins of beasts and sent through the public arena pursued by fierce dogs, which tore them to pieces for the amusement of the assembled crowds. On the occasion of a public festival in his public gardens, Nero had a number of Christians smeared all over with pitch, and at his command the pitch was set aflame and the unfortunate Christians were made to burn as living torches.

The Roman Struggle in Britain. During his reign took place the famous rising in Britain under Boadicea, "the British Warrior Queen." Boadicea was the wife of a British king who ruled over the Iceni, a people occupying that part of England now known as Norfolk and Suffolk. When her husband died, one of the Roman commanders in the island seized the territory, made the queen a prisoner, brutally scourged her, and ill-treated her daughters. Boadicea escaped from her captors and raised a large army to defend the British soil. Her army, defeated the Romans at Colchester, occupied London, and destroyed in their battles, so Tacitus tells us, some 70,000 Romans. Boadicea's victory seems to have been only a sudden surprise which disarranged the preparations of the Roman garrison. The Roman governor of the island was absent in Anglesey when Boadicea's movement broke out, but, returning, advanced against her and inflicted an overwhelming defeat on her army. The historians state that the Roman army had only 10,000 men, while the British forces numbered 200,000, and that the British loss amounted to 80,000 killed, while that of the Romans did not exceed 400.

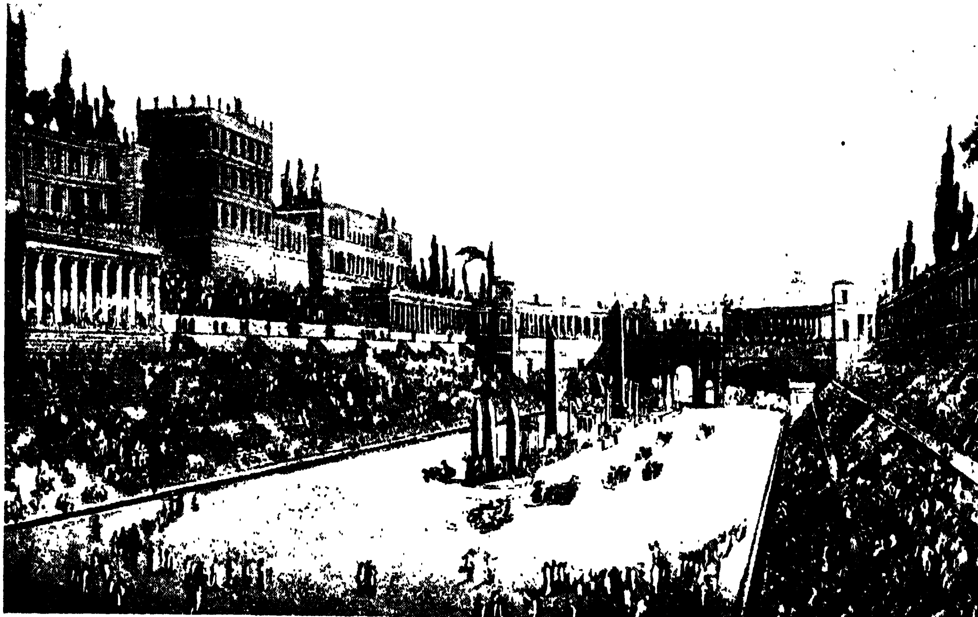
Soldier-made Rulers. Nero's wild excesses and frantic tyranny had their inevitable result. The disgusted legions in the west proclaimed their general, Galba, emperor. He marched on Rome from Spain; even the prætorians deserted Nero, who fled from the capital and shortly afterward committed suicide. Galba's reign was very short, lasting only about seven months. The lavish gifts which the soldiery expected from him did not come, and historians credit Galba with the honourable declaration that he chose his soldiers, but did not and would not buy them. Galba, during the short opportunity given him, did not display much capacity for dealing with a great crisis, and made himself conspicuous only by his extreme parsimony and reckless severity when he met with opposition. There was a rising of the soldiers against him, chiefly inspired by Otho, a former friend of Nero, and an ambitious man. Otho was proclaimed emperor, and Galba was put to death.

In the meanwhile a new claimant had arisen. This was Vitellius, the commander of the Roman legions on the Rhine. Vitellius, although he had never displayed great military qualities, had succeeded in making himself popular with his soldiers, and when the rising against Galba took place the legions of the Rhine proclaimed him emperor. His troops marched to Italy, and defeated the troops of Otho in a decisive battle. This defeat so disheartened Otho that he killed himself, and thus left Vitellius master of the political and the military field. Vitellius was proclaimed emperor at Rome. But he was nothing more than an incompetent glutton.

The Rise of Vespasian in the East. The period was one of great anxiety for Rome. There was a great rising in the Jewish provinces, and the army sent to subdue the insurrectionists was destined soon to make an historic name. This was Vespasian. Born of a humble family, he had shown much capacity for political and military life, had risen in the army, served in Germany and Britain, and now held the command in Syria. The Roman troops in the east, taking example from the legions of the west, now thought the time had come for them to assert their right of election, and in the city of Alexandria proclaimed Vespasian emperor.

The Building of the Coliseum. The troops from the Danube marched upon Rome to support Vespasian, who was himself detained in Egypt, while his son Titus was conducting operations against Jerusalem. Vitellius was deserted by his followers, and put to death, and Vespasian was acclaimed in Rome, where he arrived ere long. The utter destruction of Jerusalem by Titus, and the dispersion of the Jews, who no longer had a land of their own, are notable events of Vespasian's reign. The emperor's rule was very much like that of our Henry VII. He was resolved to establish order and economy, and had no objection to being called sordid, but he removed many unfit and corrupt office-holders who had been put into power by Nero and other emperors. He reorganised the financial system, which was in utter confusion; restored the Capitol, which had been reduced to ruins by a great fire; built the Coliseum, and established a great public library. Wherever and whenever money was wanted for any purposes of value to the State and the public, he always had an open hand. Vespasian's health broke down in A.D. 79,

THE SPECTACULAR CENTRE OF ANCIENT ROME



A CHARIOT RACE IN THE CIRCUS MAXIMUS, WITH THE PALACES OF THE CÆSARS ON THE LEFT

A RELIGIOUS PROCESSION PASSING THE TEMPLE OF CASTOR AND POLLUX IN THE FORUM, ROME

and he went to recruit his strength to his country home in the Sabine mountains, but the removal came too late to effect any change in his condition, and in the middle of that year he died.

A Brief but Memorable Reign. Vespasian's successor was his son Titus, the conqueror of Jerusalem. The impression produced upon the world by his brief reign of two years is expressed in the well-known anecdote that when he felt himself unable to recall any generous act performed by him since sunrise he exclaimed, "My friends, I have lost a day." Yet the conspicuous event of his reign was a terrific calamity. At the opening of November, A.D. 79, a tremendous eruption of Vesuvius brought destruction on some of the neighbouring towns, among which Pompeii and Herculaneum were almost entirely destroyed by a flood of lava. Herculaneum was buried under masses of ashes and lava, and its actual site was only rediscovered in 1720, when the sinking of a well brought the workers to the remains of many of its buildings. Pompeii was more fortunate than Herculaneum, because it stood farther away from the burning mountain, and was covered not so much with the destroying lava as with ashes. The city was, however, completely hidden from sight for many centuries.

The Age of Satire. Titus was succeeded by his brother Domitian. During the earlier part of his reign he pursued a course of moderation and justice, but later began to reveal the jealousies and passions that afterwards made his reign a calamity. We can read impressive descriptions of the worst chapters of his reign in the life of Agricola, by Tacitus, and his vices and his wanton cruelties are pictured in the satires of Juvenal. His death was what might have been expected from his life. There were several conspiracies against him, and one proving successful brought him and his reign to an end.

On Domitian's death, the soldiery quietly permitted the Senate to make choice of the elderly civilian Nerva as the new emperor, but Nerva strengthened his position at once by adopting as his junior colleague and heir the extremely capable and successful Trajan, commander of the legions on the Rhine. Nerva was not endowed with much physical energy, and his reign only lasted for two years. The news of Nerva's death and of his own succession reached Trajan at Cologne, where he was engaged in important work for the maintenance of peace along the frontiers and the better discipline of the army. He made no haste to go to Rome, and spent some months over his work in Germany. Then he returned, and, according to his own desire, entered Rome on foot, with his empress, Pompeia Plotina, at his side.

A Great Emperor. Trajan was well qualified for the imperial dignity. He began his reign as a reformer, and in certain paths of reform he remained consistent to the end. He greatly reduced the amount of taxation, and sold for the public benefit many palaces which some of the emperors preceding him had obtained by confiscation. He employed much of the public money for the help of the poor, and especially for their children. He restored to the Senate much of the power which had been taken from it by some of his despotic predecessors. He promoted public works partly as a means of finding work for the unemployed, the making of roads, the draining of marshes, and the creation of new seaports, some of which were created at his own cost.

He founded a great library, and caused the erection of many splendid public monuments, among them the Trajan Column. Especially noteworthy is his "rescript," or instruction, to the provincial governor Pliny concerning the persecution of Christians. They were not to be hunted down, but people who refused to sacrifice to the "Deity of Rome and the Empire" must suffer the penalty of high treason if they persisted after admonition.

Imperial Expansion. Besides being a great ruler, Trajan was a great and ambitious soldier, who extended the Empire. His reign saw as many military enterprises and invading expeditions as that of any Roman emperor. Some of these he conducted himself. He created by conquest the Roumanian provinces, which still retain on the Danube the traditions of old Rome, and brought many Asiatic regions under the sway of Rome. Historians tell us he declared that if he were a younger man he would undertake the subjugation of the Indies. But his conquests were not, in most cases, of a lasting character. He died, while engaged in military operations in the Far East, in August, 117, after a reign of nearly twenty years. Trajan left no son, but had nominated as his successor his kinsman Hadrian.

The new Emperor displayed many great qualities as a statesman. He abandoned as far as possible the policy of conquest in the East which his predecessor had followed, and showed, indeed, little inclination for war. He endeavoured to secure Rome's possessions in Britain against the daring incursions of the Caledonians by constructing the famous wall from the mouth of the Tyne to the Solway Firth, some fragments of which still survive.

Roman Art. Hadrian passed a great part of his life travelling through his dominions in order that he might acquire a close personal knowledge of their conditions, and of the improvements that might be made. He strove also to preserve peace with foreign states, and gave no encouragement to the national ambition for conquest. Many public works of general utility were constructed during his reign, and he left to his country many splendid monumental records of his love for art and architecture. He died in 138, after a reign of twenty-one years. Hadrian very wisely named as his successor the noble Antoninus Pius. His reign will ever be remarkable for the fact that he was the first Roman emperor who tried to put a stop to the persecution of the Christians. He took care that the finances of the State were administered with economy. His grateful people gave him the title of "Father of the Human

THE BEGINNING OF THE END OF ROME

NERO THE CRUEL WITNESSING THE GREAT FIRE IN ROME

A ROMAN ORGY IN THE DECADENT DAYS OF THE IMPERIAL CITY

Race." His reign was altogether peaceful, containing no record of war more serious than some expeditions for the suppression of disorders here and there on the frontiers. He died in his seventy-fifth year, leaving as his successor Marcus Aurelius, whom he had adopted.

The Reign of Marcus Aurelius. Marcus Aurelius was called "The Philosopher," and his "Meditations" well established his claim to the title. He was tried by many severe troubles during his reign—there were incessant risings among the tribes on the frontier of the empire; there were devastating earthquakes in many parts of Italy, and a destructive

EQUESTRIAN STATUE OF MARCUS AURELIUS

pestilence raged for a long time in Rome. Marcus Aurelius sold the jewels and other treasures of his imperial palace in order to meet the expenses imposed upon him by the wars and other calamities. He was, indeed, as innocent of any share in the creation of those wars as he was in the creation of the earthquakes and the pestilence, but he devoted himself as unsparingly to the mitigation of the one set of troubles as of the other. Though not a great soldier, and no lover of war, he took part in the frontier campaigns as a matter of duty; and while on one of these campaigns he fell ill and died. The only cloud on the fame of Aurelius was that, unlike his predecessor, he encouraged the persecution of the Christians.

A Failure in Heredity. Marcus Aurelius was succeeded by his son Commodus, who was but nineteen. He had served with his father in the war then going on, and as he had no inclination for military service he concluded a peace on almost any conditions, taking many thousands of the "barbarians" into employment in the Roman armies. When peace was restored, and he returned to Rome, he soon became a sort of later Nero. He was as cruel as he was profligate, and scattered death sentences so broadly against some of the noblest and best of his subjects that it became impossible for his rule to be longer endured, and he was murdered.

The authors of the plot immediately proclaimed Pertinax, prefect of the city, emperor. He was recognised by the Senate, but was unpopular with the soldiers, who put him to death eighty-six days later. Then the soldiery literally put the Empire up to auction. But though they found an ambitious, if incompetent, purchaser, the provincial armies adopted their own generals as candidates; and in the strife which ensued the victory fell to the commander on the Danube, Septimius Severus, an African by birth.

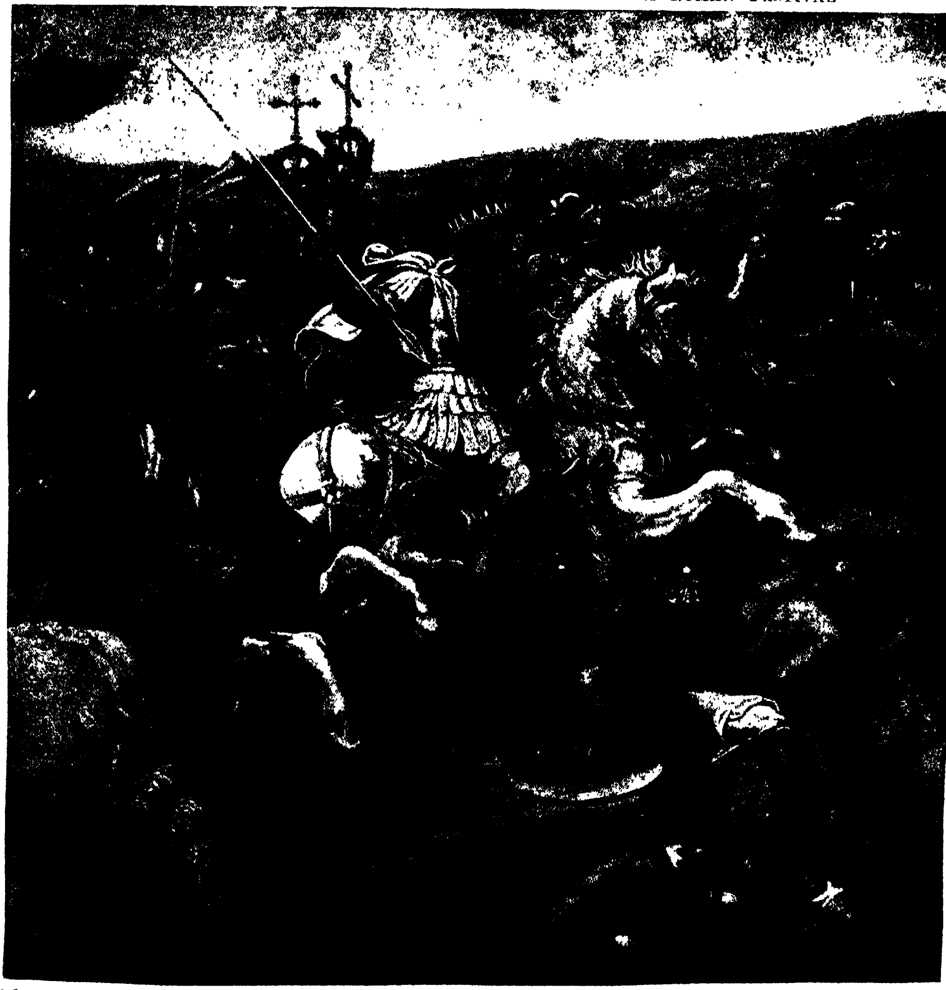
The Emperor who Died in Britain. Severus was an able soldier, and he also proved careful and economical in his administration of the finances. He attempted some wars of conquest, and subdued rebellions in the provinces. In Britain he lost so many soldiers in struggles with the Caledonians that he found it convenient to raise another great wall of defence to shelter the southern regions. He was the last vigorous and capable ruler for a long time. He died at York, and was succeeded by the son who is always known by his nickname, Caracalla, though his real name was Bassianus.

Caracalla's reign was one of cruelty and outrage. He had his brother Geta put to death, and charged a large number of Geta's friends with having plotted with him against his own imperial position; he further carried out a course of actual slaughter among all whom he suspected of participation in that conspiracy. More than 20,000 victims, it is declared, perished in this outburst of Caracalla's fury. Caracalla had six years of senseless cruelty, until a centurion whom he had injured ridded the country of him. His reign included one notable event—all the subjects of the Empire were admitted to full Roman citizenship, and to service in the legions.

A Chaos of Kings. For nearly seventy years, emperor followed emperor as some group of legionaries willed, in the East or the West. The wife of Severus had two great-nephews, who were brought up in Syria. The elder, best known as Elagabalus, enjoyed the imperial purple and a brief period of wild debauchery before he was assassinated. His brother, the amiable Alexander Severus, was permitted a reign equally brief. The Teutonic hordes, Allemanni and Goths, were surging on the banks of the Rhine and the Danube. One emperor, Decius, fell fighting valiantly against the Goths; otherwise he is remembered for his fierce persecution of the Christians. Valerian was taken captive by the Persians, who had overthrown their Parthian rulers. Claudius smote the Goths in a great battle, and then died. His successor, Aurelian, had great military capacity, and in many of his characteristics was superior to most of his recent predecessors, but

THE OLD ORDER CHANGETH, YIELDING PLACE TO NEW

A CHRISTIAN PROTESTING IN THE ARENA DURING A ROMAN FESTIVAL



CONSTANTINE THE GREAT DEFEATING THE EMPEROR MAXENTIUS AT THE BATTLE OF MILVIAN BRIDGE, WHICH ESTABLISHED A NEW ERA FOR CHRISTIANITY

his time was taken up in resisting invasions, and in conducting expeditions for the suppression of outbreaks. He is best remembered among modern readers because of his war against Zenobia, Queen of Palmyra, who is famous for her intelligence, her charms, and her plans for the creation of a great Eastern Empire. She was, however, completely defeated, and made captive. After being carried through Rome in the victor's triumphal procession, she was given a fine residence at Tibur, where she passed the remainder of her days. Aurelian did his best to restore order in the government of Rome and discipline in the army, but he came to his end, in the year 275, by the hand of his own secretary, who, being accused of extortion by his master, probably thought his only chance of escape lay in the assassination of the emperor.

one sovereign just before her extinction as the great ruling power of the world. Constantine was much drawn towards the Christian faith, and soon after becoming sole emperor of Rome he issued a decree giving civil rights and full toleration to Christians throughout the Empire. It is told of Constantine by his biographers that in one of his military marches he saw in the sky a cross of light bearing the inscription which, in English, is "In This Conquer," and the sight first filled him with the belief that the faith typified by the cross must have a Divine origin.

The Official Change to Christianity. With Constantine, Christianity ceased to be a persecuted sect, and became instead the recognised religion of the greater part of the Empire. The organised Church became an authoritative power in the state. Meanwhile he had resolved to remove the seat of empire from Rome to Byzantium (Constantinople), for the reason, no doubt, that he believed Rome to have outgrown her power as a capital, and that her dominions could best be preserved by establishing a seat of empire in some Eastern city. He named after himself the city we now know as Constantinople, and lived there in peace for the remainder of his life. Before his death he received public baptism as a Christian. He died in May, 337, and with his death may fitly end the history of ancient Rome. Rome had ceased to be a ruling empire. Ere long new races of people were to submerge the whole Roman system, and after many years of chaos a new Europe was to emerge.

THE CAPTURE OF ZENOBIA, QUEEN OF PALMYRA, BY THE ROMANS

Augusti and Cæsars. After chaos the sceptre was seized by a Dalmatian soldier in high command by sheer ability. Diocletian saw the unwieldiness of the vast Empire, and devised the plan of naming a second "Augustus" and two "Cæsars," each having control of a quarter of the Empire, while he retained the fourth quarter, with a supreme authority over all. His own seat was in the East, and Rome practically ceased to be the first city of the Empire. Under his rule occurred the fiercest of all the persecutions of the Christians, now a very large community. But it was also the last.

When Diocletian abdicated, a strife arose for supremacy among the "Augusti" and "Cæsars," and the victory fell to Constantine the Great. He brought Rome back to the rule of

A. D. INNES

Regulations and Procedure in Obtaining Orders for Tramways, Canals, Town Planning Schemes, Electricity, and other Public Works.

PARLIAMENTARY POWERS

PARLIAMENTARY work consists of the preparation of plans and sections for projected schemes before Parliament having reference to railways, canals, harbours, docks, waterworks, gas, tramway, and various other kinds of engineering schemes.

The plan and sections should agree from actual measurements on the ground, the one being co-existent with the other, the fences and other objects being properly delineated in their lateral position, so that the engineer for the scheme, on the appearance of the petitions and subsequent efforts, may sustain the allegations against his work by the opponents to the Bill, and that his plans may successfully pass upon Standing Orders.

The necessary details are very rarely obtainable without the surveyor and his staff having, in some shape or form, to trespass upon the property of others, and it should be kept clearly in mind that, under such circumstances, it is essential to fulfil one's duties with as little chance of offending the owner or occupier as possible, and to avoid doing any damage.

Qualities in the Surveyor. By courtesy and consideration in field work, the surveyor will enhance his position and command the respect of a landowner, whom, at a future date, he may meet either as a promoter or objector of the projected scheme. He must be qualified to act as witness, arbitrator, or umpire—three qualifications which demand the most careful training. As a witness, he must have clear opinions and clear reasons for holding them, and these opinions he must be able to express in concise and lucid language. As an arbitrator, he should have the qualities of an advocate, discriminating those points most favourable to his own case, and lucidly enforcing them. As an umpire, he shall have the qualities of a judge, skill and judgment in weighing evidence on both sides, and in selecting only the material points.

Projected Schemes. The regulations regarding the preparation and deposit of plans and sections for projected schemes are best explained by giving extracts from the Standing Orders of the Houses of Parliament affecting private Bills.

In cases of Bills of the second class, a plan and also a duplicate thereof, together with a book of reference thereto, and a section and also a duplicate thereof, as hereinafter described, and in cases of Bills of the first class, under the powers of which any lands or houses may be taken or used compulsorily, and in the case of all Bills by which any charge is imposed upon any lands or houses, or any lands or houses are rendered liable to have a charge imposed upon them in respect of any improvement, a plan and duplicate thereof, together with a book of reference thereto, shall be deposited for public inspection at the office of the clerk of the peace for every county, riding, or division in England or Ireland, or in the office of the principal sheriff clerk of every county in Scotland, and where any county in Scotland is divided into districts or divisions, then also in the office of the principal sheriff clerk, in or for each district or division, in or through which the work is proposed to be made, maintained, varied, extended, or enlarged, or in which such lands or houses are situate, on or before November 30th immediately preceding the application.

Railway Bills. In the case of railway Bills, the Ordnance map on the scale of 1 in. to a mile, with the line of railway delineated thereon, so as to show its general course and direction, shall be deposited with such plans, sections, and book of reference; and the clerks of the peace or sheriff clerks, or their respective deputies, shall make a memorial in writing upon the plans, sections, and books of reference so deposited with them, denoting the time at which the same were lodged in their respective offices, and shall at all reasonable hours of the day permit any person to view and examine one of the same, and to make copies or extracts therefrom; and *one* of the two plans and sections so deposited shall be sealed up and retained in the possession of the clerk of the peace or sheriff clerk until called for by order of one of the two Houses of Parliament.

Alteration of Boundaries. In cases of Bills whereby it is proposed to alter or extend the municipal boundary of any city, borough, or urban district, a map on a scale of not less than 3 in. to a mile, and also a duplicate thereof, showing as well the present boundaries of the city, borough, or urban district as the boundaries of the proposed extension, shall be deposited with the town clerk of such city or borough, or clerk of such urban district, who shall at all reasonable hours of the day permit any person to view and examine such map, and to make copies thereof; and a copy of the said map, with the said boundaries delineated thereon, shall also be deposited at the office of the Board of Agriculture and Fisheries.

On or before November 30th a copy of the said plan, sections, and books of reference, and, in the case of railway Bills, also a copy of the Ordnance map, with the line of railway delineated thereon, shall be deposited in the Private Bill Office of this House.

Electric Schemes. In cases of Bills for the supply of electrical energy, an Ordnance map on a scale of not less than 1 in. to the mile, with the proposed area of supply marked thereon, shall be deposited at the office of the Board of Trade on or before November 30th. Where

district councils apply to the Local Government Board for sanction to loans for purposes of electric lighting, the Local Government Board require to be furnished with plans and sections of any proposed buildings, and a general plan showing the portion of all the proposed works, distributing mains, and the limits of the district to be lighted by the installation.

The following are the maximum terms allowed by the Local Government Board for loans for purposes of electric lighting: For land, 60 years; building, 30 years; cables, 25 to 20 years; engines, transformers, instruments, and house services, 15 years; motors, 10 years; motors and arc lamps, 5 years.

Tidal Lands. In cases where tidal lands within the ordinary spring tides are to be acquired, or in any way affected, a copy of the plans and sections shall, on or before November 30th immediately preceding the application for the Bill, be deposited at the office of the Harbour Department, Board of Trade, marked "Tidal Waters," and on such copy all tidal waters shall be coloured blue, and if the plans include any bridge across tidal waters, the dimensions, as regards span and headway of the nearest bridges, if any, across the same tidal waters above and below the proposed new bridge, shall be marked thereon; and in all such cases such plans and sections shall be accompanied by an Ordnance map of the country over which the works are proposed to extend, or are to be carried, with their position and extent or route accurately laid down thereon.

Riverside Schemes. In cases where the work is to be situated on the banks, foreshore, or bed of any river, a copy of the plans and sections shall, on or before November 30th immediately preceding the application for the Bill, be deposited:

1. If the river is in England or Wales, at the office of the Board of Agriculture and Fisheries.
2. Or, if the river is in Scotland, at the office of the Secretary for Scotland.
3. Or, if the river is in Ireland, at the Irish Office, Westminster, and at the office of the Department of Agriculture and Technical Instruction for Ireland, Dublin.
4. And if the river is subject to a board of conservators, at the office also of such board.

And if the plans include any tunnel under or bridge over the river, the dimensions as regards depth below bed of the river, and span and headway, shall be marked thereon; and such plans shall be accompanied by an Ordnance map of the country over which the works are proposed to extend or are to be carried, with their position and extent or route accurately laid down thereon.

Local Authorities. Where, under the powers of any Bill, any work is intended to be made, maintained, varied, extended, or enlarged, or any lands or houses may be taken or used compulsorily, or an improvement charge may be imposed, a copy of so much of the said plans and sections as relates to any of the areas hereinafter mentioned, together with a copy of so much of the book of reference as relates to such area, shall, on or before November 30th, be deposited with the officer respectively hereinafter mentioned—that is to say, in the case of (*a*) The City of London, with the clerk to the London County Council. (*b*) Any borough in *England* or *Wales*, whether metropolitan or other, the town clerk of such city or borough; (*c*) Any urban district in England or Wales, not being a borough, the clerk of the district council; (*d*) Any parish in England or Wales having a parish council, the clerk of the parish council, or, if there is no clerk, with the chairman of that council; (*e*) Any parish in England or Wales comprised in a rural district, and not having a parish council, with the chairman of the parish meeting, and the clerk of the district council; (*f*) Any burgh in Scotland, the town clerk or clerk; (*g*) Any parish in Scotland, outside a burgh, the clerk of the parish council; (*h*) Any urban or rural district in Ireland, the clerk of the district council.

Deposit with State Departments. Where any Bill power is sought to have any churchyard, burial-ground, or cemetery, or any part thereof, or to disturb the bodies interred therein, or where power is sought to take any common or commonable land, as the case may be, a copy of so much of the plans, sections, and books of reference required by these orders to be deposited in the Private Bill Office in respect of such Bill as relates to such churchyard, burial-ground, or cemetery, common or commonable land, shall, on or before November 30th, be deposited at the office of the Secretary of State for the Home Department, and a copy of so much of the said plans, sections, and books of reference as relates to such common or commonable land shall, on or before the said day, be deposited at the office of the Board of Agriculture and Fisheries. Wherever any plan, sections, and books of reference, or parts thereof, are required to be deposited, a copy of the notice published in the "Gazette" of the intended application to Parliament shall be deposited therewith.

Description of Plans. Every plan required to be deposited shall be drawn to a scale of not less than 4 in. to a mile, and shall describe the lands which may be taken or used compulsorily, or on which an improvement charge may be imposed, or which are rendered liable to the imposition of an improvement charge, and in the case of Bills of the second class shall also describe the line or situation of the whole of the work (no alternative line or work being in any case permitted), and the lands in or through which it is to be made, maintained, varied, extended, or enlarged, or through which any communication to or from the work may be made; and where it is the intention of the promoters to apply for powers to make any lateral deviation from the line of the proposed work, the limits of such deviation shall be defined upon the plan, and all lands included within such limits shall be marked thereon; and unless the whole of such plan shall be upon a scale of not less than a quarter of an inch to every 100 ft., an enlarged plan shall be added of any building

yard, courtyard, or land within the curtilage of any building, or of any ground cultivated as a garden, either in the line of the proposed work or included within the limits of the said deviation, upon a scale of not less than a quarter of an inch to every 100 ft.

Canals, Reservoirs, or Waterworks. In all cases where it is proposed to make, vary, extend, or enlarge any cut, canal, reservoir, aqueduct, or navigation, the plan shall describe the brooks and streams to be directly diverted into such intended cut, canal, reservoir, aqueduct, or navigation, or into any variation, extension, or enlargement thereof respectively, for supplying the same with water.

In cases of Bills for improving the navigation of any river there shall be a section which shall specify the levels of both banks of such river; and where any alteration is intended to be made therein, it shall describe the same by feet and inches, or decimal parts of a foot.

The powers of a local authority are limited. The Public Health Act, 1875, prohibits the construction of any waterworks within the limits of any water company so long as any such company are able and willing to supply water proper and sufficient for all reasonable purposes for which it is required by the local authority.

Street Tramway Bills. In cases of Bills for laying down a tramway, the plans shall indicate whether it is proposed to lay such tramway along the centre of any street, and, if not along the centre, then on which side of and at what distance from an imaginary line drawn along the centre of such street, and whether or not, and if so, at what point or points it is proposed to lay such tramway, so that for a distance of 30 ft. or upwards a less space than 9 ft. 6 in., or if it is intended to run thereon carriages or trucks adapted for use upon railways, a less space than 10 ft. 6 in., shall intervene between the outside of the footpath on each side of the road, and the nearest rail of the tramway.

All lengths should be stated on the plan and section in miles, furlongs, chains, and decimals of a chain. The distances in miles and furlongs from one of the termini of each tramway shall be marked on the plan and section. Each double portion of tramway, whether a passing-place or otherwise, shall be indicated by a double line. The total length of the road upon which each tramway is to be laid shall be stated —that is, the length of route of each tramway. The length of each double and single portion of such tramway, and the total length of such double and single portions respectively, shall also be stated.

In the case of double lines (including passing-places) the distance between the centre lines of each line of tramway shall be marked on the plans. This distance must in all cases be sufficient to leave at least 15 in. between the sides of the widest carriages and engines to be used on the tramways when passing one another. The gradients of the road on which each tramway is to be laid shall be marked on the section. Every crossing of a railway, tramway, river, or canal shall be shown, specifying in the case of railways and tramways whether they are crossed over, under, or on the level.

All tidal waters shall be coloured blue.

All places where, for a distance of 30 ft. and upwards, there will be a less space than 9 ft. 6 in. between the outside of the footpath on either side of the road and the nearest rail of the tramway, shall be indicated by a thick dotted line on the plans, on the side, or sides, of the line of tramway where such narrow places occur, as well as noted on the plans, and the width of the road at those places should also be marked on the plans.

The preceding paragraph shall apply, in the case of a tramroad, wherever it is carried along a street or road.

The Tramway Act, 1870. Under the Tramway Act, 1870, the promoters intending to make applications for a provisional order shall proceed as follows:

In the month of October and November next before application, and in any one of these months, they shall publish notice of their intention to make such application by advertisement, and they shall, on or before the fifteenth day of the following month of December, serve notice of such intention, in accordance with the Standing Orders (if any) of both Houses of Parliament for the time being in force with respect to Bills for the construction of tramways.

All maps, plans, and documents required by the Act to be deposited for the purposes of any provisional order may be deposited with the persons and in the manner directed by the Parliamentary Documents Deposit Act, 1837.

The promoters shall give to the Board of Trade at least fourteen days' notice in writing of their intention to open any tramway or portion of a tramway, accompanied by

(*a*) A copy or tracing of so much of the deposited plans and sections as relates to the portions of tramway proposed to be opened, distinguishing between double and single line, and showing, in red ink, any variations therefrom in the tramways so constructed;

(*b*) A list of the local and road authorities concerned; a diagram of the lines submitted for inspection of such authorities of about 2 in. to a mile.

Town-Planning Schemes. The object of the town-planning part of the Housing and Town-Planning Act, 1909, to quote from a circular issued by the Local Government Board, is "to ensure, by means of schemes which may be prepared either by local authorities or landowners, that in future land in the vicinity of towns shall be developed in such a way as to secure proper sanitary conditions, amenity and convenience in connection with the laying out of the land itself, and of any neighbouring land."

In London, the County Council, and, elsewhere, the borough, urban, or rural district council, is the local authority for town-planning purposes. Schemes may be made in respect of any land which is in course of development, or which appears likely to be used for building purposes. Authority must first be obtained from the Local Government Board, and the

scheme, when prepared or adopted, will require the approval of that body, and, where objection is taken by a person or authority interested, either House of Parliament may intervene. The Local Government Board are empowered to prescribe a set of general provisions for carrying out the general objects of town-planning schemes, and such provisions will be incorporated in every scheme, so far as they are not varied or excluded in special cases. The Local Government Board are also empowered to make regulations governing the procedure on the preparation and submission of town-planning schemes.

Once the scheme has been approved, the responsible authority will have full power to enforce it by pulling down buildings which contravene its provisions, or by executing work in cases where delay in the execution of such work by the person responsible for it would prejudice the efficient operation of the scheme. Provision is made for the payment of compensation to a person whose property is injuriously affected, and, on the other hand, for the recovery of one-half of the increment by the responsible authority where the scheme increases the value of any property.

Building under Town-Planning Schemes. There is perhaps no single provision in the Housing and Town Planning Act which is of more importance than that permitting a town-planning scheme to limit the "number of buildings which may be erected on each acre, and the height and character of those buildings," taken with the further provision that such limitation shall not entitle the owner of the property to compensation in regard to "any provisions inserted in a town-planning scheme which, with a view to securing the amenity of the area included in the scheme, or any part thereof, prescribe the space about buildings or limit the number of buildings to be erected, or prescribe the height or character of buildings, and which the Local Government Board, having regard to the nature and situation of the land affected, consider the limitation reasonable for the purpose of securing the amenity of the area included in the scheme."

There is considerable difference of opinion as to how far this limitation of the number of buildings to be erected on each acre of land should be carried. Before attempting to decide this question, it is important to consider exactly what is the effect of reducing or increasing the number of houses per acre on any given area of land. At first sight it will appear to property owners that if the number of houses which may be erected on any acre of land is reduced to one-half of what is permitted by local by-laws, the value of the land will be reduced by something approaching this proportion.

Promoting a Town-Planning Scheme. The work involved in the promotion of a scheme other than the mere clerical work may be summarised as follows:

(1) The ascertainment of the names of owners, lessees, and occupiers, and the service upon them and the local authorities interested, by post or otherwise, of notices or other documents upon at least five occasions. The regulations require that at least two meetings of interested persons must be held for the discussion of the proposed scheme. If no more than two are held, the notices of such meetings could be served together with one other of the prescribed notices, so that the occasions for service need not exceed five.

The Local Government Board have reduced the cost of this work in individual cases by dispensing with service of notices on occupiers at less than quarterly tenancies, and also on allotment holders.

It appears that the names of the owners and other persons interested in a scheme can only be obtained by a house to house inquiry, and great care is essential, for the omission of names may jeopardise the scheme, or involve the authority in serious liabilities. It is to be regretted that no surer and more expeditious way of ascertaining these names could be devised, for this work contributes a serious item to the cost.

(2) The preparation and supply of copies of seven maps. The maps numbered 1, 2, 4, 5, and 7 are to be on the scale of 25·344 ins., map No. 3 on the scale of 1 in., and map No. 6 on the scale of 6 in. to the mile. These maps are to be Ordnance maps, mounted on linen. Map No. 2 is map No. 1 repeated with fuller details; map No. 5 is map No. 4 with amendments, if such are necessary.

The Necessary Maps. The regulations require that a certified copy of map No. 1 shall be furnished by the responsible local authority to other local authorities affected by the scheme, but the Local Government Board have allowed a map on the scale of 6 in. to the mile to be substituted. These maps are required to indicate all existing and projected buildings, roads, open spaces, and lines of sewers and pipes or mains for the supply of water, gas, or electricity, with such descriptions and measurements as are required by the regulations. Map No. 7 is required to indicate the ownerships of the land, the names being indicated on the map itself or by reference to an accompanying book. The first step in the preparation of these maps is to post the Ordnance map up to date, but this may be regarded as part of the ordinary administrative work of the local authority; it is not a cost properly attributable to the town-planning scheme. It will no doubt be found necessary, in respect of the hilly areas, to contour the maps more closely than is done by the Ordnance Survey.

The work involved in the preparation of these maps is practically the measure of the work of preparing the scheme.

(3) Printing of the various notices, draft order, and approved order for service on all persons interested.

(4) Seven advertisements to appear each in one or more local newspapers, giving notice of the different stages in the preparation of the town-planning scheme.

A. TAYLOR ALLEN

The Leading Dramatic Poets and Playwrights from the Seventeenth Century to the Present Day

THE DRAMA SINCE SHAKESPEARE

No comparison is possible between the drama of the Elizabethans and that of their immediate successors. It is all contrast—the contrast, one great critic has said, of Hyperion and a satyr. We shall not go so far as that. But all the brilliancy of the "comic dramatists of the Restoration" cannot blind us to the fact that when women made their first professional appearance on an English stage, the chief theme of the plays written at the time was ridicule of the marriage state, to the end that the ribald laughter of a dissolute Court might be provoked and the cheap cynicism of "the man of the world" encouraged.

The why and the wherefore of a study of the Restoration drama are so admirably set forth in one of Macaulay's "Essays"—the review of Leigh Hunt's edition of the Works of Wycherley, Congreve, Vanbrugh, and Farquhar—that we can hardly do better than commend this essay to the reader at the outset.

The first name that claims our attention is that of SIR WILLIAM DAVENANT (b. 1606; d. 1668). Davenant's work well reflects the spirit of reaction against Puritanism; much of it was unworthy of the man's better parts. His "heroic play" of the "Siege of Rhodes" is the germ of English opera, and he introduced many accessories to the theatre, including the orchestra. THOMAS KILLIGREW (b. 1612; d. 1683) is the author of a comedy, "The Parson's Wedding," which, we are told by Pepys, was originally acted by a female cast. He built a playhouse in 1663 on the site of Drury Lane Theatre.

JOHN DRYDEN (b. 1631; d. 1700), at the instance of Davenant, wrote an absurd adaptation of "The Tempest," and a capital blank verse tragedy, "All for Love," on the lines of "Antony and Cleopatra." He adapted the "heroic couplet" to the English drama, thus winning the approval of Charles II. and the ridicule of the Duke of Buckingham in "The Rehearsal." His characters are, in the main, abstractions; he uses noble language to convey ideas full of extravagance. But his tragedies of "Don Sebastian" and "Cleomenes," together with the comedies of "Marriage à la Mode" and "The Spanish Friar," contain much that is eminently readable. Avowedly, he wrote plays not because the work was congenial, nor because he thought of posterity, but to make money. Considering the variety of his literary output in other directions, it is remarkable that his position as a dramatist stands as high as it does. The student should not miss his "Essay on Dramatic Poesy."

WYCHERLEY (b. 1640; d. 1715) was one of the two great lights of Restoration comedy. Said Evelyn, the famous diarist, with reference to this dramatist:

> "As long as men are false and women vain,
> Whilst gold continues to be virtue's bane,
> In pointed satire Wycherley shall reign."

Like Dryden, Wycherley made a rather feeble first effort at writing for the stage. Also like Dryden, but with greater success, he sought and found inspiration in France and Spain. He may be described as the originator of our comedy of manners. "He was a ruffian," says Mr. Gosse, "but a ruffian of genius." He was a faithful mirror of his own time. His chief comedies are "The Plain Dealer" and "The Country Wife." The one is founded on Molière's "Le Misanthrope," and is praised by Hazlitt as "a most severe and poignant moral satire"; the other loses our respect and much of such admiration as its workmanship claims when compared with its sources, Molière's "L'Ecole des Maris" and "L'Ecole des Femmes." Wycherley's own life provides the most effective satire on the social ideals of his period.

In the works of WILLIAM CONGREVE (b. 1670; d. 1729) the comedy of manners attains its summit. "The Old Bachelor," "The Double Dealer," "Love for Love," "The Mourning Bride," and "The Way of the World" were all written before their author was thirty years old. Then came sinecures and literary sterility. Congreve was, and remains, a master of repartee and accomplished insolence. He

wrote better than Molière; but Molière's stage method and dramatic style preserve his plays alive, while those of Congreve, if we except "Love for Love," which has been described as the finest prose comedy in the English language, are consigned to the study. "In every point," writes Mr. G. C. Ewald, "Congreve maintained his superiority to Wycherley. Wycherley had wit, but the wit of Congreve far outshines that of every comic writer, except Sheridan, who has arisen within the last two centuries. Congreve had not in a large measure the poetical faculty; but, compared with Wycherley, he might be called a great poet. Wycherley had some knowledge of books, but Congreve was a man of real learning. Congreve's offences against decorum, though highly culpable, were not so gross as those of Wycherley, nor did Congreve, like Wycherley, exhibit to the world the deplorable spectacle of a licentious dotage."

Some phrases from the Congreve comedies long since passed into the common speech: "Music hath charms to soothe the savage breast," "Heaven has no rage like love to hatred turned, nor hell a fury like a woman scorned," "Married in haste, we may repent at leisure" are among those most often quoted.

Vanbrugh and others. What Sir John Vanbrugh (b. 1664; d. 1726) lacked in grace he had in coarse wit and facile inventiveness. The epitaph

> "Lie heavy on him, earth! for he
> Laid many heavy loads on thee,"

alludes to his achievements as the architect of Blenheim and Castle Howard, not to his authorship of "The Relapse," "The Provoked Wife," and "The Confederacy." With Vanbrugh may be compared George Farquhar (b. 1678; d. 1707), who, in some directions as a dramatist, improved on his predecessors in cogency of construction, and whose incidental verse indicates a power that—possibly for reasons connected with a hand-to-mouth sort of existence—was never fully cultivated. The famous line from his "Twin Rivals"—

> "Necessity, the mother of invention"

—is singularly apposite to its author. Horace Walpole said of Farquhar's plays that they talk the language of a marching regiment in country quarters. He wrote best what he wrote last, "The Recruiting Officer" and "The Beaux' Stratagem." He marks the transition from Restoration licence towards the purer, if more conventional, stage methods belonging to the reign of Queen Anne and the Early Hanoverians.

Thomas Otway. In Thomas Otway (b. 1651; d. 1685), it has been well observed, "there is no relief, no pause from the war and clamour of passion." He lived tragically, wrote tragedy, and died young. Gloomy as are his plays, and devoid of lyrical beauty, they reach the heart by sheer force and knowledge of human nature. "More tears," said Sir Walter Scott, "have been shed probably for the sorrows of Belvidera [in "Venice Preserved"] and Monimia [in "The Orphan"] than for those of Juliet and Desdemona." Of "Venice Preserved," which awakened the praise of Dryden, Hazlitt, and Taine, versions have been made in French, German, Dutch, Russian, and Italian. Otway is a strayed tragedian, belonging by genius, if not by time, to the Elizabethans.

The Lesser Dramatists. Other names that can only be given bare mention as those of dramatists of some, but lesser, note are: Colley Cibber (b. 1671; d. 1757), who appears to have been better as a comedian than as a playwright, though his version of Shakespeare's "Richard III." has been frequently performed in the provinces even of recent years; Nicholas Rowe (b. 1674; d. 1718), whose "Jane Shore" is still acted, and who, in "The Fair Penitent" (adapted from Massinger's "The Fatal Dowry"), drew the prototype of Richardson's Lovelace; John Gay (b. 1688; d. 1732), author of "The Beggar's Opera" and the libretto for Handel's "Acis and Galatea"; and Richard Savage (d. 1743), who wrote a comedy, "Love in a Veil," a tragedy, "Sir Thomas Overbury," and inspired Dr. Samuel Johnson to the writing of one of the best, if by no means the most accurate, of short biographies.

Brief mention must also be made of Joseph Addison (b. 1672; d. 1719) as the author of "Cato," a tragedy which has enjoyed in literature a European reputation; Sir Richard Steele (b. 1672; d. 1729), "the father of sentimental comedy"; Samuel Johnson (b. 1709; d. 1784), as the author of "Irene," a tragedy which all Garrick's zeal could not make successful, and concerning which Boswell has some entertaining pages; Samuel Foote (b. 1720; d. 1777), a social satirist in Johnson's vein; David Garrick (b. 1717; d. 1779), whose adaptations, together with his prologues and epilogues, are of merit; George Colman the elder (b. 1732; d. 1794), who collaborated with Garrick in "The Clandestine Marriage," and wrote "The Jealous Wife"; and George Colman the younger (b. 1762; d. 1836), author of "The Heir-at-Law," a comedy of sterling qualities.

Goldsmith and Sheridan. Oliver Goldsmith (b. 1728; d. 1774) was unlucky in the circumstances attending the production of the first of his two comedies, "The Good-Natured Man." It was poorly acted, but genius prevailed. The lovable qualities found in all he wrote distinguished both "The Good-Natured Man" and "She Stoops to Conquer." These two comedies, the proceeds of which made their author for the time being a man of fortune, have been referred to as the greenest spots in the dramatic history of the period to which they belong, and as containing "wit without licentiousness, humour without extravagance, brilliant and elegant dialogue, and forcible but natural delineation of character." Richard Brinsley Sheridan (b. 1751; d. 1816) is as popular on the stage as Shakespeare. To the graceful humour of Goldsmith he added the wit, without the grossness, of Congreve. Of his four comedies, "The Rivals," "The School for Scandal," "The Critic," and "The Duenna," the first and second are the best known.

Of Sheridan's comic muse Hazlitt says: "She does not go prying about into obscure corners or collecting idle curiosities, but shows her laughing face and points to her rich treasure, the follies of mankind. She is garlanded and crowned with roses and vine-leaves; her eyes sparkle with delight, and her heart runs over with good-natured malice; her step is light, and her ornaments are consummate."

The Drama of the Nineteenth Century. When the nineteenth century opened, Shakespeare shared with Goldsmith and Sheridan all the distinctive honours. The other dramatists, in the stage sense of the term, were hard to seek. "MONK" (MATTHEW GREGORY) LEWIS (b. 1775; d. 1818), of "The Castle Spectre"; THOMAS HOLCROFT (b. 1745; d. 1809), author of "The Road to Ruin"; and JAMES SHERIDAN KNOWLES (b. 1784; d. 1862), who wrote "The Hunchback" and "The Love Chase," are among the best of the playwriters of the time.

SAMUEL TAYLOR COLERIDGE (b. 1772; d. 1834) wrote a tragedy, "Remorse," which, says Mr. Swinburne, contains "little worth praise or worth memory, except such casual fragments of noble verse as may readily be detached from the loose and pliable stuff in which they lay embedded." It ran for twenty nights at Drury Lane, in 1813. Another half-forgotten tragedy of the period is that of "Bertram," by the Rev. CHARLES ROBERT MATURIN (b. 1782; d. 1824), which was produced by Kean at Drury Lane, in 1816, on the recommendation of LORD BYRON (b. 1788; d. 1824), whose own contributions to literary drama—"Manfred," "Marino Faliero," "Sardanapalus," "The Two Foscari," "Cain," "Heaven and Earth," "Werner," and "The Deformed Transformed"—are dealt with in connection with his poetry, as will "The Bride's Tragedy," of THOMAS LOVELL BEDDOES (b. 1803; d. 1849); and "The Cenci," by PERCY BYSSHE SHELLEY (b. 1792; d. 1822). Byron's plays found their way to the stage for other reasons than their intrinsic value for acting purposes. "Ion," a Greek tragedy by Sir THOMAS NOON TALFOURD (b. 1795; d. 1854), and "Philip van Artevelde," by Sir HENRY TAYLOR (b. 1800; d. 1886), are both works for the reader, rather than for the playgoer. "Philip van Artevelde" is a romance that has received far too little attention in recent years.

The Dramas of Lord Lytton. One of the most popular of the dramatists of the nineteenth century was EDWARD BULWER, LORD LYTTON (b. 1803; d. 1873), whose plays, "The Lady of Lyons," "Money," and "Richelieu," for all their artificialities of sentiment, still retain a strong hold upon the public. This is also the case with such plays as "Society," "Caste," and "Ours," by THOMAS WILLIAM ROBERTSON (b. 1829; d. 1871); "Masks and Faces" and "It is Never too Late to Mend," by CHARLES READE (b. 1814; d. 1884); "Black-Eyed Susan," by DOUGLAS JERROLD (b. 1803; d. 1857); and "London Assurance" and "Colleen Bawn," by DION BOUCICAULT (b. 1822; d. 1890). Comedy lightened into burlesque and extravaganza on the one hand, the work of PLANCHÉ, the brothers BROUGH, HENRY JAMES BYRON, and others; and on the other, into sparkling operas, of which those composed by Sir ARTHUR SULLIVAN (b. 1842; d. 1900) and Sir WILLIAM SCHWENCK GILBERT (b. 1836; d. 1911) are incomparably the best.

The Literary Dramas of Browning and Tennyson. While comedy was degenerating, the purely literary drama was receiving some noteworthy additions in "Strafford," "A Blot on the 'Scutcheon," "The Return of the Druses," and "Luria," by ROBERT BROWNING (b. 1812; d. 1889); the "Queen Mary," "Harold," "Becket," and "The Foresters" of ALFRED TENNYSON (b. 1809; d. 1892); and "The Queen Mother," "Rosamond," "Atalanta in Calydon," "Chastelard," "Bothwell," "Mary Stuart," "Erechtheus," "Marino Faliero," "The Sisters," "The Tale of Balen," and "Rosamund, Queen of the Lombards" of ALGERNON CHARLES SWINBURNE (b. 1837; d. 1909); and the "Demeter" and other plays of ROBERT BRIDGES, now Poet Laureate (b. 1844).

The Stage in the Twentieth Century. Until nearly ten years of the twentieth century had passed, it seemed as if the modern English drama was doomed to be an echo of the French stage, except for the plays of a few writers, among whom the most conspicuous were Sir ARTHUR PINERO (b. 1855), author of plays as dissimilar as "Sweet Lavender" and "The Second Mrs. Tanqueray"; and Mr. HENRY ARTHUR JONES (b. 1851), author of "The Silver King" and "The Liars." But a new spirit has stirred to life the dry bones of the theatrical valley of death. A share in the revival is due to the freshening influence of Mr. GEORGE BERNARD SHAW, some of whose plays almost continuously hold the stage. But the revival has been stimulated from several quarters, notably by the rise of a new provincial drama. This comes from quarters wide apart and takes many forms, as in the short, strange, fascinating Irish plays of JOHN MILLINGTON SYNGE (b. 1871; d. 1909); the strong Lancashire play "Hindle Wakes," by STANLEY HOUGHTON (b. 1881; d. 1913); the grim Yorkshire play "Rutherford and Son," by Miss SOWERBY; and the delightful Scottish characterisation of Mr. GRAHAM MOFFAT in "Bunty Pulls the Strings" and "A Scrape o' the Pen."

The Best Features of Modern Plays. But on the London stage, too, a graver grip of life, a deeper humour, and a sweeter poetical fancy have been manifest in one or other of such works as Sir JAMES BARRIE'S plays, culminating in "Peter Pan"; Mr. JEROME K. JEROME'S "The Passing of the Third Floor Back"; Mr. JOHN GALSWORTHY'S "Strife," "The Pigeon," and "Justice"; the profoundly moving "Milestones" of Mr. ARNOLD BENNETT (b. 1867) and M. E. KNOBLAUCH; and the lovely fantasy of Mr. MAURICE MAETERLINCK'S "Blue Bird." There has also been a return to a true use of the spectacular in drama, as illustrated in the patriotic production of "Drake," the classical presentation of "Œdipus Rex," the mediæval "Miracle," and the Oriental "Kismet."

Appointments under a Typical Council. Junior Clerks and their Prospects. Draughtsmen. Women Typists.

MUNICIPAL CLERKSHIPS

The incomes of municipal clerks vary almost indefinitely, according to the duties they perform, and the liberality or otherwise of their employers. At the head of the calling are such responsible positions as principal clerkships under the City Corporation, with salaries ranging between £650 and £1000 a year. The other extremity is occupied by temporary office clerks, performing routine duties for a bare £1 a week. Between these extremities lies every imaginable gradation in value and dignity; and as there is no uniformity of system in the Service, each local authority being a law unto itself, the vast bulk of clerical employment is too incongruous to admit of precise classification. To this general want of system, however, there are many exceptions, the most notable case being that of the London County Council, whose clerical staff is separately considered in the course of this chapter.

An Expert's Views. The courtesy of a distinguished municipal officer enables us to present to our readers an admirably clear and comprehensive summary of the general prospects afforded by clerical employment in a corporation of average size. After premising that special factors may influence the progress of every clerical staff, the expert proceeds as follows.

"Generally it is the practice for corporation clerks to start as juniors or office boys at salaries ranging from £15 to £25 a year, the necessary qualifications being, as a rule, that the lad is of good character, has had a fair education, and (in most cases) shows a good knowledge of figures. Junior appointments are sometimes filled on the recommendation of head masters of public schools who have pupils leaving school and desirous of getting into the Municipal Service.

"In the large departments of the corporation, such as gas, water, electric lighting, or public works, these juniors would progress into counter, rental and exchange clerks, accountant and ledger clerks, cashiers, collectors, and district clerks, with maxima of about £150 to £180 a year. The work of these clerks is in the most cases routine, but exceptional ability may be rewarded with positions as chief clerk, office superintendent, and departmental accountant, with salaries ranging from about £250 to £500.

"In the Treasurer's Department the same rule as to juniors may be said to exist. Here a good knowledge of figures and some bookkeeping skill are special qualifications. Appointments as cashiers and ledger clerks are usually recruited from the junior staff, and salaries range from £80 to £250 a year. In this department, also, there are higher appointments, as chief bookkeeper, chief accountant, and other posts, with salaries running up to about £500 a year.

"With regard to the Town-clerk's Department, a rather higher standard of education is required here than is the case with the other departments of the corporation. Appointments of committee clerks are usually held by the town-clerk's staff, with salaries varying from about £200 to £300 a year. In this department are law clerks, and parliamentary, registration, and election clerks, with salaries ranging from £100 to about £350 a year. In nearly all cases these appointments are filled by clerks who have gradually progressed to their position by long service and experience."

Junior Clerkships. The broad plan thus ably sketched is subject in particular instances (as its writer expressly concedes) to many modifications. A number of borough councils, for example, prefer to recruit their clerical staff by taking into their service, at more substantial salaries, youths between the ages of 17 or 18 and 21 years who have already had some special training for office life. In such cases a knowledge of shorthand and typewriting, or experience in a commercial office, is usually essential; and the remuneration, starting at some figure between £45 and £70 a year, advances annually £5 or more to a maximum of £80, £100, or £120. Promotion to higher posts, while always based upon ability and merit, is in some municipal offices dependent on the occurrence of suitable vacancies.

How to Enter. A lad for whom a municipal clerkship is desired should be trained to write a good clerkly hand, rapid if possible, but, at all costs, distinctly legible. Commercial arithmetic, and especially the ability to manipulate large masses of figures without a mistake, is more valuable to him than uncertain flights in higher mathematics. A knowledge of shorthand and typewriting and the rudiments of bookkeeping are also very serviceable acquisitions.

As soon as the aspirant is moderately adept in these studies, which should be in or about his sixteenth year, the town-clerks of several suitable corporations should be approached. The larger the boroughs, of course, the better are the prospects of a vacancy. From the head official, particulars can be obtained as to the qualifications required of candidates, the age limits imposed, and the method by which vacancies are filled. If the prevalent practice is followed of maintaining a "waiting list" of suitable candidates, all that remains is to comply with whatever formalities are requisite for the insertion of the student's name, and to continue his training while awaiting notice of a vacancy. It may be, however, that the lists are already overburdened with prior claims, or that appointments are advertised—though this

latter method is not generally adopted in respect ot office youths and junior clerks. Recourse should then be had to other authorities; and meantime the announcements of municipal vacancies referred to in previous chapters should be carefully scanned, and application made for such junior positions as are advertised, until a suitable post is secured and the youth is launched on his official career.

Prizes of the Clerical Service. Under many leading authorities there are higher clerical posts occasionally accessible as heads of departments, committee secretaries, and so forth. The City Corporation, as already mentioned, offers several such prizes. The principal clerk of the public health staff, who has 38 years brilliant service to his credit, receives £1800 a year, and his colleagues in the chamberlain's and town-clerk's office £1000 each. Clerical appointments worth from £500 to £750 a year are similarly won from time to time by men of outstanding ability in almost every busy corporation.

Necessity of Specialising. Such prizes are captured by the men who, being neither routine-bound nor content with the bare qualifications exacted by their work, have specialised as their judgment suggested. And this course is essential for the clerk who is not only ambitious, but resolved to realise his ambitions. Having chosen his work, he must sedulously fit himself for higher office than he holds. Is public health to be his forte? While still a junior he will study the statutes and by-laws, familiarise himself with the system by which they are applied, and by lending a willing hand in the preparation of minutes and reports, and in a score of other ways, will make his services valuable to the chief clerk and the medical officer. In the Municipal Service, controlled as it is to a great extent by amateurs, there is always need of such experts, and they have good prospects of early advancements.

Draughtsmen and Tracing Clerks. These officers, although members of the general clerical staff, constitute a small and special section, unaffected by the ordinary conditions of promotion. They are employed in the departments of the surveyor, engineer, and architect, in the preparation of plans, and allied work. The earnings of tracing clerks are small—from 15s. to 50s. a week. Plan copiers earn from £130 to £180 a year, and the salaries of draughtsmen range between £80 to £100 a year for junior appointments, and £180 or £200 for seniors. A number of draughtsmen and technical assistants are employed by the London County Council's superintending architect (of Spring Gardens, S.W.), who will forward forms of application upon request. These posts are on the "unestablished" staff, and are remunerated at rates

THE TOWN HALL AT MANCHESTER

ranging from a guinea (for youths) up to 4½ guineas a week. The latter figure is rarely exceeded, or even reached, in this branch of the Municipal Service. Unless, therefore, the draughtsman has received an outdoor training which will qualify him for an assistant surveyorship, his prospects are restricted.

L.C.C. Clerkships. The London County Council recruits its staff of men clerks from time to time by open competitions resembling those of the Civil Service Commissioners. There are three examination schemes of differing severity, which admit to positions of corresponding value. The first grade is for men clerkships. These examinations are open to British subjects who are over 18 and under 23 years of age on the last day for receiving applications—which is usually a few weeks before the contest begins. Candidates must be free from physical defects, and are required, if successful, to undergo a medical examination before being appointed.

The competitions are held as often as a further supply of junior clerks becomes necessary. They are advertised in the chief daily newspapers for several months beforehand. Latterly, examinations have taken place yearly, and a score or more candidates have been selected on the result of each.

Salaries. The clerical staff of the L.C.C. is classified as follows:

Second class, £80, rising by £5 yearly to £100, by £10 to £150, and by £12 10s. yearly to £200.

First class, £200, rising by £15 to £245, and by £15 and then £20 yearly to £300.

Clerks are probationers for the first year of their service, and the annual increment in every case is dependent on satisfactory conduct. There are some 300 first-class and 700 second-class officers on the staff. Beyond these grades are certain special appointments, such as senior assistants (£300 to £400) and principal assistants (£400 to £700), which are usually filled by the promotion of subordinate officers. Second-class clerks are promoted to the first class according to merit.

Pension and Provident Scheme. Unlike the majority of local bodies, the London County Council has a liberal pension and provident scheme in operation, to which each official "on the establishment" pays 2½ per cent. of his salary, being thereupon credited by the Council with more than double that amount.

The existing staff regulations afford no guarantee of special promotion beyond the £300 limit. However, in view of the regular and fairly liberal increments this employment affords, and the probability that the Council's activities will continue to develop, the opening presented by such a clerkship to a youth of 18 or 20 is certainly a fair one.

Examination Notes. Details of the competitions for L.C.C. clerkships are furnished by the schedule on page 1119. There are several supplementary points, however, to which the attention of candidates should be directed.

Competitors are exempted from Part I. of the examination if they have passed it at a prior contest under the present scheme, or hold a matriculation, higher local, or senior local certificate, or have passed certain other educational tests.

Examination in General Knowledge. Among the novel features of Part II., the most striking is the compulsory examination in general knowledge. This is an ingenious test of the candidate's observation, memory, and intelligent grasp of facts. Its scope can best be judged by these specimen questions from a typical paper:

What do you know of the voyage of the "Bounty," Bushido, the Terrible Cornet of Horse, the Father-in-Law of Europe, Leander, the Magzhen, the "Mayflower," May Meetings, Pidgin English, the Scourge of God?

Explain the phrases: *Savoir faire; Lèse majesté; Welt politik; Res judicata; Territorial waters.*

What do you know of the Round Towers of Ireland, the Towers of Silence, and Martello Towers?

Give the English names for the following places: Anvers, Bruxelles, Firenze, Gênes, Genf, Köln, Londra, Marrakesh, Napoli, Venedig; and state what nations employ these designations respectively.

Classify the British Dominions beyond the sea according to the nature of their respective governments, and state as shortly as you can the points of difference between the several forms of government.

Explain precisely why a ship floats in the sea, and a balloon in the air, and why it is more easy to steer a ship than a balloon.

Definitely to prepare for such questions as these is almost beyond the art of man. Occasional readings in a concise encyclopædia might do much towards it, provided that every passage thus encountered is carefully read through. It will be found that several questions in each set relate to topical or political matters treated in the daily Press.

Special Papers. Subject 13—Central and local government—is a useful study for future municipal servants; but, despite the textbooks recommended by the Council's syllabus, it is exceedingly difficult to master this topic unaided. Fortunately, however, several Civil Service colleges prepare candidates in this and all other subjects for the L.C.C. examination.

Shorthand, bookkeeping, and accountancy are the subjects of a special memorandum. They may be taken in Part II. as special papers, but not for inclusion in the competitive examination. This course is adopted because "there are some positions in the Council's service," as the regulations state, "where shorthand is desirable, and others where bookkeeping is essential," and as that authority specially reserves the right to appoint a candidate out of the order of merit, if he is qualified for a particular post, a good stenographer or bookkeeper may win an appointment, even though he takes only a moderate place on the general list.

Minor Establishment Posts. These posts for men and youths in the subordinate ranks of the London County Council's staff are filled, like men clerkships, by means of open competitions. Particulars of the examinations will be found in the schedule on the next page. In the general intelligence test for youths, they are allowed to study a long narrative for 15 minutes, but not to make notes, and are then questioned as to its general purport and its details.

Youths in the minor establishment receive 15s. a week, rising to 25s., and may be advanced to the men's grade. In this the rate of pay is 27s. 6d., increasing to 40s., and possibly to 60s. a week. In every case the annual increment is fixed at 2s. 6d. a week. Beyond £3 weekly there is no prospect, as members of this staff are not eligible for promotion to men clerkships. Ten per cent. of the vacancies at each examination for men clerks, however, are reserved for limited competition among assistants of the minor establishment who have served for six years, are over 24 years old, and have been nominated by their official chiefs.

Women Typists. The London County Council employs some 120 of these officials, who are selected by means of preliminary and competitive examinations open to women between the ages of 18 and 30. The qualifying test is restricted to arithmetic, English composition, history, geography, and typewriting, including stencil work, but candidates may take shorthand in addition. For Class II. the rate of pay is £55, rising by £5 annually to £65, and in the upper section to £80. Class I. officials, beginning at £80, advance by a like increment to £100, and on gaining the upper section rise from £100 to £120. ERNEST A. CARR

LONDON COUNTY COUNCIL CLERKSHIP EXAMINATIONS

Examining Body, Time and Place of Examination.	SUBJECTS OF EXAMINATION. PART I. Candidates holding certain certificates are exempt. PART II. Shorthand and Bookkeeping may be taken as non-competitive but useful subjects [see Letterpress].	Fees and Age Limits.
THE LONDON COUNTY COUNCIL, Spring Gardens, S.W. When requisite: usually once each year. London.	MEN CLERKSHIPS. **Part I. Preliminary** (*all subjects are compulsory*). 1. Handwriting } marked from papers 3, 5, and 6. 2. Orthography } 3. English Composition (Essay writing). 4. Arithmetic, including mensuration and use of logarithms. 5. English History, including a special period. 6. Geography, including the United Kingdom and another special section. 7. Mathematics: Euclid, Books I.-IV., and VI., or equivalent geometry. Algebra, to binomial theorem. Plane trigonometry to solution of triangles.	10s. 18 to 23 years.
	Part II. Competitive. 1. General Knowledge (*compulsory*). 2. Précis Writing (*compulsory*). *Any four of the following may also be taken:* 3. English Language and Literature: including essay and special periods. 4. Pure Mathematics: (i.) higher algebra; (ii.) higher trigonometry and geometry, calculus. 5. Applied Mathematics: analytical statics, particle dynamics, etc. 6. and 7. Modern Languages (two): Translation from and into. 8. Latin: Translation from and into. 9. English History, including a special period. 10. Geography, including British Isles and another special section. 11. History of London. 12. Economics: theory and history, policy of tariffs, etc. 13. Central and Local Government: functions of authorities, rates and taxes. 14. Experimental Mechanics: use of apparatus, mechanical principles, etc. 15. Experimental Physics: laws and phenomena, simple measurements. 16. Chemistry, practical and theoretical. Note: In subjects 1, 3, 6, 7, 14-16, the examination is both written and oral. Practical knowledge of experimental methods is essential in 15 and 16.	10s. 18 to 23 years.
LONDON COUNTY COUNCIL, Spring Gardens, S.W. When requisite: about once a year.	MINOR ESTABLISHMENT: MEN. **A. Compulsory.** 1. Handwriting. 2. Orthography. (Both marked from paper 3.) 3. English Composition (Essay). 4. Arithmetic, with compound addition. 5. General Knowledge. 6. Précis Writing. **B. Optional.** *Any two among*—Typewriting, Shorthand (80 words a minute), French, German, Drawing (freehand or geometrical), Bookkeeping. (Note: Typewriting and Shorthand carry extra marks.)	5s. 20 to 30 years.
	MINOR ESTABLISHMENT: YOUTHS. **A. Compulsory.** 1. Handwriting. 2. Orthography. (Both marked from paper 3.) 3. English Composition (Essay). 4. Arithmetic, general. 5. English History, with special period. 6. Geography, with special sections. 7. General Intelligence Test. **B. Optional.** *Any two among*—Typewriting, Shorthand (60 words a minute), French, German, Elementary Experimental Science, Drawing (freehand or geometrical). (Note: Typewriting and Shorthand carry extra marks.)	2s. 6d. 15 to 18 years.

Full particulars, with a detailed syllabus of subjects, can be obtained from the Clerk of the London County Council, Spring Gardens, S.W. The papers set at past contests are supplied by Messrs. P. S. King and Son, 2, Great Smith Street, Westminster, S.W., at 1s. 2d. per set, for second-class posts, and 7d. for minor appointments, post free. Approaching examinations are advertised in the leading London newspapers.

THE DIVISION OF THE CELLS OF LIFE

These five pictures show the progress of the division of a cell. In the first cell we see the nucleus in globular form with the chromatin thread coiled within it. The two black spots to the right are the two divisions of the centrosome, which we see attached to the nucleus of the typical cell shown on page 198. They take up positions at opposite poles of the nucleus, as in 2. The chromatin thread divides into the chromosomes, which split lengthwise, as shown in 3 and 4, and are then drawn mysteriously towards the centrosomes, with which each group forms a separate nucleus, and the whole cell divides into two separate and complete cells as shown in 5.

The Reproduction of the Simplest and Highest Forms of Life. The Wonderful Work of the Nucleus of a Cell.

THE NUCLEUS OF THE CELL

Though every complete and perfect living cell contains a nucleus, there are some exceptions, and, like all exceptions in science, they mean something and must be carefully noted. A white blood-cell has a nucleus, like an amœba, but a red blood-cell has none. Here seems to be a strange exception to the rule, for almost wherever else we turn in our own bodies, we find nucleated cells—whether in brain or bone or muscle or gland.

However, when we examine the history of the blood, we find that all the red cells had nuclei once. In cases where red cells are needing to be made at an unusual rate (because some poison or disease, perhaps, is destroying them too fast), we find nucleated red cells in the blood. Also, we learn something about the functions of nuclei in general when we find that the red cells which have lost their nuclei have a very humble function, are little more than sacs of hæmoglobin, make no spontaneous movements of their own, and cannot reproduce themselves, but die without progeny. It is just because these higher functions are not required of them that they do not need their nucleus after the stage at which they are formed by division of preceding cells. We are about to learn that the nucleus is the master of cell-division.

The Origin of Bacteria. Yet another exception first, however. Microbes have no nuclei. Now that many minute unicellular animal parasites have been discovered, like the trypanosomes of sleeping sickness, the term *microbes* is getting to be applied to them. They all have nuclei, however. It is the bacteria, the "microbes" to which Pasteur originally gave the name, that have no nuclei; and the fact is very remarkable. It may be explained in one of two ways, and it certainly needs explanation, for the nucleus plays such a part in practically all living cells everywhere—the amœba or the cells of the brain which we use as we read—that we are astonished to find living races which consist of cells that have no nuclei at any stage in their history.

It may be that the bacteria represent a form of life so humble as not yet to have reached the stage of organisation represented by the nucleus. This is the view of the famous old survivor from the battle-days of evolution, Professor Ernst Haeckel, of Jena. If we believe that the bacteria represent the beginnings of life, or at least the visible beginnings, we need not expect them to possess nuclei. Nor need we do so if we accept the remarkable experiments which Dr. Charlton Bastian is still carrying on, and which are now, at last, being repeated by other workers.

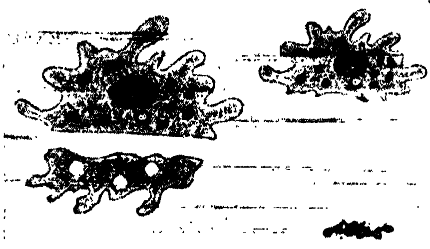
Dr. Bastian's Experiments. According to Dr. Bastian, simple bacteria can be formed from inorganic solutions *of a colloidal kind* (as Professor Moore has significantly commented); and if this be so, the absence of a nucleus in the bacterial cell must be taken as a primitive character. But we do not yet know whether Dr. Bastian's results will be verified by other observers; and we are certain that, even if they be so verified, they will not suffice to explain the natural origin of bacteria, for bacteria cannot live without the help of other and higher kinds of life originating in the *green* cell. Probably, therefore, microbes are *degenerate*, and it may very well be that their ancestors had nuclei, though they have not. The student must not regard the question as settled, but he should be on the look-out for news of the important experiments now afoot for the solution of this fascinating and profoundly important question.

Reproduction of Microbes by Fission. We have already hinted that the nucleus is all-important for the reproduction of the cell. What, then, of cases where there is no nucleus? In our own bodies, as instanced by the red blood corpuscle, or by the very surface cells of the skin just before they are shed, the loss of the nucleus means that the cell cannot divide. With the nucleus goes the possibility of the continuance of the vital stream in that cell. But the microbes are different. It is quite possible that, within them, invisible by our best microscopes, there are portions which are nuclear in function; and we can only surmise the rearrangements and allocations of the living material which occur when a microbe divides into two. But all that we can see is almost crudely simple. The microbe *splits*. Most microbes, we know, are bacilli—rod-shaped cells. Such a cell splits, along its length—and then there are two. Technically, this process is called *fission*—the Latin for splitting—and there is no more to say about it, simply because no more can be discovered. Therefore we may leave the microbes, but we have already learnt the name of the simplest known method of reproduction in the world of life.

The Gemmation of the Yeast Cell. A little higher in the scale is the kind of fungus we find forming the yeast-plant. The round cells of yeast are higher in type than the round cells we call cocci. When a coccus reproduces itself it simply acquires a waist, so to say, and then divides into two. That comes under what we have already called fission. But a yeast cell *buds*. A little portion of it swells beyond the general surface, and is then budded off. Sometimes a short string of such "buds" may be

seen, and then the individual "buds" are detached, assume the full size of a yeast cell, and the process is complete.

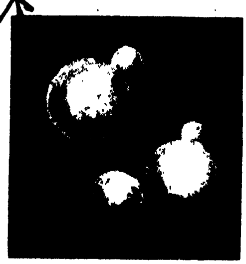
The technical name for this, the second type of reproduction in the world of life, is *gemmation*, which is Latin for budding. About this, also, there is no more to say, for we cannot discern any further details through the miscroscope. Both in the case of fission and in that of gemmation, however, we shall be very wrong if we do not realise that very subtle and intricate chemical processes must be at work, under the guidance of ferments, before the cell reproduces itself, even in these apparently simple ways we have described.



THE LIFE POWER OF THE NUCLEUS

This picture shows what happens when a cell is cut. The portion with the dark necleus survives while the other part shrivels up and dies

The Division of the Nucleus. But these are the rarest exceptions in the world of life, though doubtless the numbers of individuals which exhibit them, among the microbes alone, must far exceed all other living individuals put together. Higher types of individual may each consist of billions of cells, however; and there is a true sense in which each of these cells is as much an individual as any microbe—or vastly more so. And the rule is that these cells have nuclei, and that, when they reproduce themselves, the nucleus initiates and controls the process. As we have learnt the scientific names of the two simpler kinds of reproduction, we may now note the third, which is called *mitosis*—that is, weaving—or *karyokinesis*—that is, nuclear-movement. The names are intended to indicate the strange things which are observed in the nucleus when it divides.



CELLS BUDDING

The yeast cells and some other simple plants reproduce themselves by budding in the way shown here

If it were possible, we should wish to be able to describe the chemistry of the nucleus before we went any further. Unfortunately we cannot go far in this direction. The dead contents of what were living cells can be analysed, but our analysis must be far from telling us what we need to know about their chemistry in life. In the poet's indignant phrase, "we murder to dissect," and many essentials are destroyed in the first process. Some elementary facts we can state.

The Chemistry of Protoplasm. Protoplasm always contains carbon, hydrogen, nitrogen, oxygen, and sulphur, not as elements in elementary form, but as constituent elements of the compounds which are peculiar to protoplasm, and of which we as yet know so little. The typical compounds found in protoplasm are, above all others, those called proteins—formerly called proteids, a term now obsolete. These proteins always contain carbon, hydrogen, nitrogen, and oxygen. But it is a notable and significant fact that cell-nuclei always contain a special kind of protein (or many such), called nucleo-protein in order to distinguish it; and these nucleo-proteins, it has been found, invariably contain phosphorus.

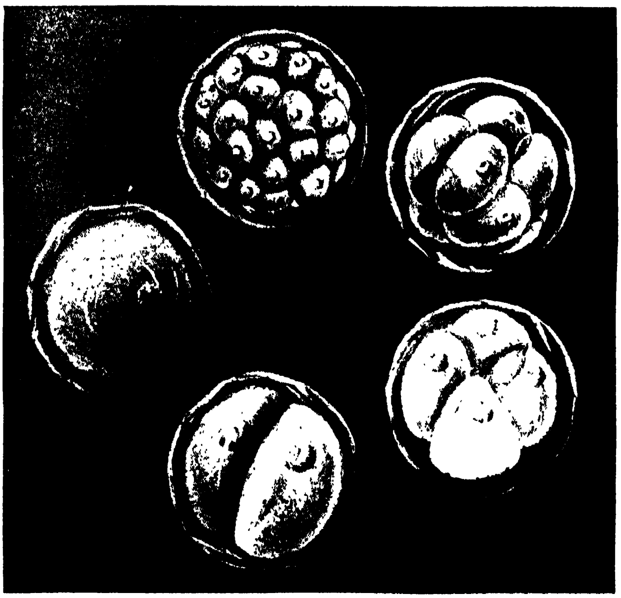
Most of us have heard the nineteenth century German saying: "Ohne Phosphor, keine Gedanke"—"without phosphorus, no thought." This was said to indicate the importance of phosphorus in the composition of the brain, and of nervous tissues generally. It is quite true that phosphorus is important in such tissues; but in fact phosphorus is an essential constituent of the nuclei of all cells whatever—a man's muscle cells, or a lobster's, or an oyster's, just as much as of the cells of the human brain. As to the part the phosphorus plays, we can say little; but much will yet be revealed by the expert chemical study of the nucleo-proteins and the part they play in the wonderful history of the living cell.

We must particularly beware of thinking that protoplasm is a thing with a definite chemical composition. In the nineteenth century, this was quite the accepted view of protoplasm, but it is not true. The nucleus of any living cell must contain many hundreds of different substances; or, rather, it must be a constantly changing mixture, or organism, of many substances which are formed and unformed and reformed continually, according to the needs of the vital processes of which the nucleus is the seat. Nevertheless, it is very important to know the names of the chemical elements which are essential for protoplasm in general, and of the further element, phosphorus, which is essential for the nucleoproteins that are found in nucleoplasm. Probably the next great step will be the identification of some, at any rate, of the special ferments that are made in protoplasm, and constitute its agents for all kinds of purposes. This study is just beginning—as, for instance, in the recent isolation of certain of the ferments by means of which the yeast cell turns sugar into carbonic acid and alcohol.

The Interdependence of the Cell-Body and the Nucleus. So important is the nucleus that the whole of the cytoplasm must be looked upon as practically no more than a kind of nutrient envelope and appendage of the nucleus. The cytoplasm is like the circle of ministers and attendants that surround a king, so that he never comes into immediate relation with the outer world. So with the cell-nucleus. Further, all these individuals depend upon the king, and will suffer if they lose their relation to him. So with the cytoplasm, or cell-body, as it is sometimes called. The cell-body nourishes the

nucleus, but the nucleus is necessary for the nourishment of the cell-body. In the case of relatively large cells it is sometimes possible to amputate a portion of the cell-body, and watch its fate. *Invariably it dies;* but the remaining portion which contains the nucleus survives and ultimately repairs itself.

The Healing Power of the Nucleus. The highest kind of cell that exists offers as perfect an illustration of this remarkable function of the nucleus as does the amœba. What we call a nerve-fibre in our bodies is really the prolongation of the body of a nerve-cell. If such a nerve-fibre be cut across, the part of it which is next the cell-body, and thus is still under the control of the nucleus, remains undamaged in itself; but the whole length of the fibre which has been cut off from the nucleus (just as in our experiment with a simple unicellular animal) degenerates, and in a few days is reduced to a row of lifeless drops of oil and rubbish, lying within the sheath that covers the fibre. But now, if the surgeon sews up the cut place, so that the sheath of the nerve is made continuous, the nerve will be regenerated; new substance will shoot down the old sheath, from the point where the cut was made and repaired, and the nerve will be whole and well again. It is the nucleus of the nerve-cell—which may be one or two feet away, in the case, say, of nerves in the leg—that has the power of repair, and can restore the cell-body and its long fibres to their normal state, just as the nucleus of the amœba can reconstruct the portion of cell-body that may have been amputated.



HOW CELLS MULTIPLY IN THE HIGHER FORMS OF LIFE

These pictures show the multiplication of the cells in a crab. On the left is seen a single cell, which divides into two, which become four, and so on. Thus cell division goes on indefinitely.

From these two cases, as extreme as they can be, but absolutely identical in principle, we learn that the nucleus has what is called a trophic, that is to say, nutritive, function; and this trophic function of the nucleus is one of the most important which it possesses, for it is, indeed, the power of life in general to nourish itself and to repair injuries. Doubtless the bio-chemists, in days to come, will be able to show that in the nucleus alone are to be found those ferments which make nutrition possible. Thus, while the cytoplasm may, and certainly does, contain food-materials, and is thus a store of nourishment for the cell as a whole, only the nucleus contains those digestive or other ferments by means of which the cell can use its food; and hence any part of the cell which is cut off from relation to the nucleus must die, and can only serve in the end as food for some other cell which is complete.

The Structure of the Nucleus. The microscope, which could not offer us unequivocal knowledge as to the structure of the cytoplasm, can give us some quite definite facts regarding the nucleus. We must apply some kind of stain or dye if we wish to see the details of structure. Cells may be dyed (and killed, of course) at all stages in their history, and then the nuclei may be studied in all these cases. Real facts of structure, not dependent upon the death of the cell, or the mode of preparation, have in this way been certainly ascertained.

The typical nucleus consists of two distinct portions. One of these does not stain very markedly, and as it therefore takes little colour it is called the *achromatin*. It seems to be the less important part of the nucleus, and to play the part, rather, of a general background or support for the rest of the nucleus, which stains very deeply, and is therefore called the *chromatin*. As a rule, this chromatin, or dyeable part, of the nucleus, is seen as a very complicated network, and the evidence which we get from other times in the history of the nucleus teaches us that this network is really a very long thread, which is all coiled upon itself, so as to occupy very little space, and to offer the appearance of a network.

The Secret of Hereditary Qualities. Of all objects upon which the eye can gaze, this nuclear chromatin is the most interesting, wonderful, and mysterious. Look at it in the case of a human germ-cell, and in it we see, as nearly as human eye can ever see, the physical basis, or condition, or medium, by which a son may resemble his father or his mother, even in such things as good temper, or musical ability, or obstinate stupidity.

For we now know that the nuclear chromatin, besides all else that it may be for the life of the individual cell, is also the bearer of the hereditary

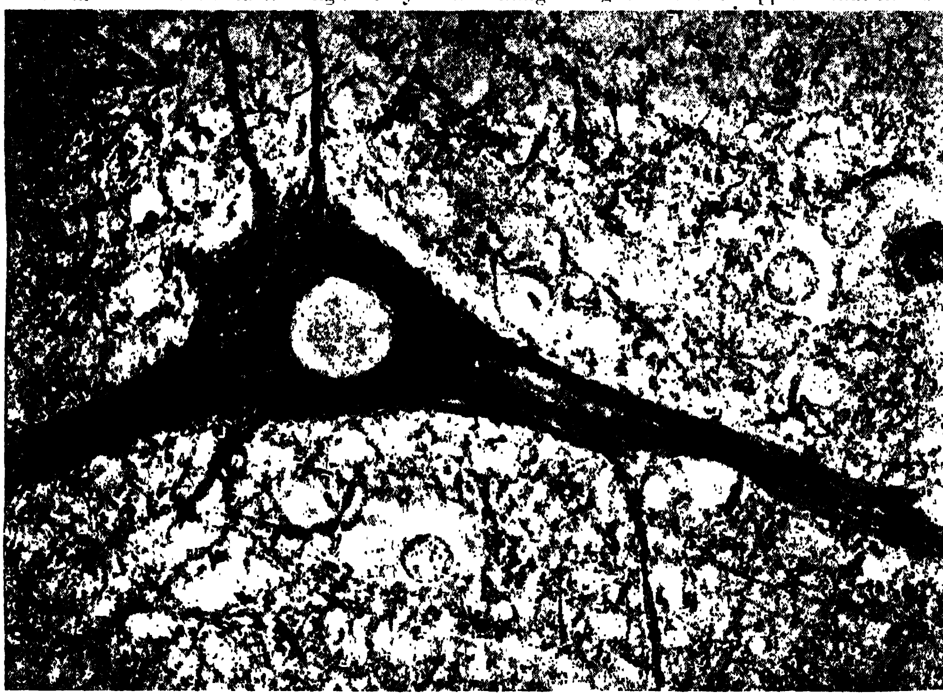
qualities which pass from any cell to its offspring. This is wonderful enough, though relatively quite intelligible, in the case of the amœba. We watch the nucleus divide, according to the rules of mitosis, and find that there has been a kind of just and exact apportionment of every particle (so far as we can see) of the nuclear chromatin, between the two cells which result from the division of the parent amœba. In biology division means multiplication, we notice; and this is a hint, perhaps, that all kinds of mathematical ideas and laws are inapplicable in the world of life.

But what shall we say of the nuclear chromatin when we see it not in a cell which is destined merely to be a single cell always, until itself divides and multiplies, but in a cell which is destined to become a human being? Only then do we realise how wonderful may be the "chromatin thread" of a cell nucleus—from which the very brain of a Shakespeare might develop.

The Formation of Chromosomes. The nucleus, as we have described it, is in what is usually called its "resting-stage." The term is quite incorrect, of course, for the nucleus is actively nourishing itself, and discharging its trophic function for the rest of the cell of which it is the nucleus; and upon it depends the discharge of the special function of the cell, whatever that may be. It may be a thinking-cell in the brain, a pulling-cell in a muscle, a secreting-cell in a gland; but in each case the special function can be discharged only when the cell nucleus is in a state of health and activity.

We call the ordinary appearance of the nucleus its "resting stage," simply in order to distinguish it from another stage which is very different in appearance and results. Not all nuclei will show this new stage, for in many cases nothing more than the maintenance of the life and duties of the cell is required of the nucleus. But in many other cases the supreme duty of reproduction is required also. The amœba does not live for ever as such. The time comes when it must reproduce itself. The germ cell which is to become a man must reproduce itself and become two cells, and they four, eight, and so on, almost *ad infinitum.*

Then it is that we observe the "active" stage or "mitotic" stage in the history of the cell nucleus. The most obvious hint that something strange is about to happen is that the chromatin network becomes uncoiled and reveals itself as a long thread. That thread then breaks up into a number of short portions, which need a special name, and are called *chromosomes,* or colour-bodies. But at this point there is another complication which we must observe.



A NERVE-CELL OF THE HUMAN BRAIN, SHOWING ITS NUCLEUS
In this very highly magnified photograph of a nerve-cell of the human brain, termed a psycho-motor cell because it controls the action of the muscles, we see the unstained centre, which is the nucleus. Upon this depends the life of the nerve seen stained and branching off from it.

The Centrosome. Outside the nucleus, but lying near it, in the cytoplasm, is usually to be seen a small, dense object, much smaller than the nucleus, and as a rule of apparently little interest. Indeed, it might be taken for a mere store of nutriment in the cytoplasm, perhaps. But the discovery has been made, by skilful microscopists, that this little object is all-important during cell-division. It is so important that it needs a name, and it is called

the *centrosome*, or centre-body—a term which is unfortunately so like "chromosome" that we must beware of confusion.

The general rule is that the centrosome shows the first signs of impending mitosis, for it divides into two, even before the changes in the nucleus begin. And gradually the two parts of the centrosome part company, and move over to opposite sides or poles of the nucleus. We are watching the beginning of what has been compared to some stately, slow, well-ordered, old-fashioned kind of dance; and the centrosome is a sort of leader of the dancers.

The Problem of Sex. These chromosomes, formed by the breaking up into "short lengths" of the chromatin thread which used to be coiled in the nucleus, are now waiting for the next stage in their strange, eventful history. Their number is no chance. It is fixed and immutable, so far as we can discover, in any given species. In the cells of a human being when they are dividing, the number of chromosomes is now stated to be always twenty-two. In the mouse, the salamander, the trout, and the lily the number is 24; in the grasshopper it is 12; in some sharks it is 36; in the onion it is 16; but the point for us to remember is that, in the words of Professor E. B. Wilson, the greatest living authority on the cell, "every species of plant or animal has a fixed and characteristic number of chromosomes, which regularly recurs in the division of all its cells."

The reader will notice that the numbers quoted above are all even, and until recently it has been supposed that the number of chromosomes is always even. But some exceptions have been discovered, and, like all true exceptions in science, they are leading us on to new discoveries. The cells which compose the growing bodies of certain insects, and which we can observe in their stages of nuclear "activity," have been found to possess an odd number of chromosomes. Where the cells of the species had been supposed to contain, say, sixteen chromosomes in the nucleus, in some cases the number has been found to be seventeen.

It is invariably the cells of the females that have this peculiarity, and so we begin to suspect that the possession of what is now called the "accessory chromosome" in the cell nucleus has something to do with the fact called femaleness, at any rate in the cases in which it has been observed. This is a department of cytology which is now being specially studied for light upon the problem of sex, its origin and meaning.

The Dance of the Chromosomes. But now the dance begins. Different observers give slightly different accounts of it, and the number of movements or steps may be described, according to taste, as six, twelve, or more. To show what happens we require the application of the cinematograph to the process, and this will shortly be done. Successive photographs must be taken of some such cell as the amœba, during the occurrence of mitosis, and then the time taken can be artificially reduced, and the observer will be able to see, in a few seconds, the dance of the chromosomes, and its consequences.

The essential fact is very simple. We saw that in the case of such a non-nucleated cell as a bacillus, multiplication occurs by fission. Just so do the chromosomes split in the dividing nucleus. Each chromosome divides accurately down its middle line, so that, when the process is complete, there are double the normal number of chromosomes in the cell. The next fact, in brief, is that these halved chromosomes sort themselves out into two companies, of equal numbers, of which one retreats toward one pole of the nucleus, and the other toward the opposite pole. The two half-centrosomes, which we have left on their way toward opposite poles of the nucleus, seem to be the directors of this process; and observers have described a sort of fine threads which seem to run between the centrosomes and the split chromosomes, and to draw the latter each to its destined place. In the upshot, we find two nuclei, instead of one, each nucleus having its own centrosome outside it, and each containing the characteristic number of chromosomes, thanks to the fashion in which each of the original chromosomes was split up. In time, in each nucleus, the individual chromosomes become attached to one another, and form a long thread again, which becomes coiled upon itself, and now the whole process of mitosis is complete. All that remains is for the cytoplasm to form a waist, and to undergo a cleavage between the two nuclei. Thereupon we have two perfect, characteristic cells, each an hereditary descendant of the single cell with which we began; and at any rate in such a simple case we need not be surprised at the law of heredity, which says that like breeds like.

An Unsolved Problem. So much, with the aid of the pictures, for the bare descriptive facts of mitosis. The suggestion remains—*how* does all this happen? What are the forces at work which will explain what we have thus described? Here, of course, is the heart of our problem. No one who has approached the study of life with any scientific ideas at all will be surprised to learn that the laws of physics and chemistry are not transgressed in this process, any more than in a ballroom. According to various recent experiments, electrical principles are illustrated in several of these "mitotic figures" and the transitions between them. Various experimenters have cleverly shown that figures which closely resemble those of mitosis can be reproduced in not-living materials, under the influence of electrical and other physical or chemical forces.

Such experiments are of great interest, and may prove to be of practical value. The writer believes that along these lines we shall do great things, for radium is known to have a special selective action upon cancer cells, and it is certain that this action is electrical in nature. But recent microscopists have shown that cancer cells are abnormal in respect of the number of chromosomes that they possess; and it is a not improbable speculation that there is a relation between this peculiarity of the cancer cell and its special sensibility to the electrical influence of radium.

C. W. SALEEBY

Arrangement of the Modern Office. Duties of Managers. Sales and Advertising Departments. Accountants. Office Discipline.

ORGANISATION OF AN OFFICE

HAVING taken a broad view of the general principles of business, we come now to a more detailed consideration of its various departments and activities, and naturally begin with office organisation, for the office is really the brain of a business. However many departments there may be, and however varied their scope and character, it is in the office that their energies are directed, their operations co-ordinated, and the impetus given to their activities which shall bring about the result of profitable trading.

This being so, it is not surprising to learn that the office of a large firm offers the best opportunities to a young and enterprising man of rising to a high position. Like Napoleon's soldier who carried in his knapsack a marshal's baton, the office boy has within him the potentialities and possibilities of a general manager or a managing director. By far the larger proportion of the high officials of our great railway companies, and the managers and heads of our large commercial businesses, have started in quite small positions in the office.

The office, then, being the brain of a business, the centre in which policy and developments are planned, and from which everything is directed, it is of supreme importance that the organisation of the office should be as nearly perfect as possible. Any flaws caused through slackness or incompetence must necessarily communicate themselves to other departments, and the business will very soon suffer. The office should be so constituted that the least irregularity, inside or out, automatically records itself, so that the cause can be instantly detected and removed without delay.

The office staff will, of course, vary according to the character of the business, but presiding over all will be a managing director or general manager, with the heads of the various departments responsible to him. The relationship may be expressed by the diagram on the next page.

Factory organisation is dealt with later. Our concern here is with the office, and first of all let it be understood that no office can be thoroughly efficient that is not housed in a suitable building. If the arrangement of the different departments is faulty, if they are scattered about so that related departments, such as the accountants' and the cashier, or the sales and the advertising, are far apart, thereby involving much running about, then valuable time is wasted which, in the course of a year, may amount literally to a loss of thousands of pounds. Unless time is economised as much as money, efficiency can never be obtained, for there is no waste more disastrous than that of time.

The arrangement of the various departments in an office must, of course, depend largely upon the space available, and the shape of the building, and also upon the character of the business; but there are general principles which must be followed in all businesses.

The manager will be settled in some convenient room, with his secretary or private clerk in an adjoining office and available at a moment's notice. Entrance to the manager's office is usually through the private secretary's room, but it is a convenience if there is another door, so that, if necessary, the manager can let in or out any visitor whom, for reasons of policy, it is not advisable should pass through the other offices.

The American system of having the various offices, even the manager's, cut off from the others merely by glass partitions is being more and more followed by progressive firms in this country, and it can then be seen by anyone at a glance who is in and who is out. The most up-to-date businesses have a system of posting up the names of the different heads of departments, so that callers and others may see at once whether the particular person they desire to interview is in the building.

The general manager should keep in touch with every department, and where necessary written reports should be submitted to him, showing daily the output of the factory, the daily sales, the amount of cheques received, the bank balance,

and so on. He will see the heads of the different departments daily, and, if possible, stated times will be alloted to each. If this is not done, there is much waste of time owing to the different heads having to wait indefinite periods for their turn. In special emergencies, various members of the staff may need to see the manager at once, and a very good arrangement is to have a bell or buzzer attached to the door. This is rung by the person desiring to see the manager, and if he is free he touches a button on his desk, which causes a small disc or sign to appear in a frame on the outside of the door. The disc has on it the words, "Come in," or "Engaged," as the case may be, and the person waiting can thus see whether or not he can be received. Where all the heads of the departments are connected by telephone with the manager's office, they can, of course, telephone through for this purpose.

So far as the regular daily interview with the manager is concerned, the heads of departments must be ready at their appointed times, and have, in a folder or letter-basket, their day's queries. In this way no valuable time is wasted by them or by the manager.

As to the arrangement of the office, the sales and the advertising departments, with the statistical, should always be adjoining, as the sales and advertising must of necessity always work together, recording and tracing results in the statistical department, to which they will be constantly referring. Where the business is a large one, the head of each department will have a private office to himself, with his staff in a larger room adjoining; and each will have his own shorthand clerk, files of letters, and so on. Sometimes this shorthand clerk works in one of the rooms of his particular department, but it is more and more getting the custom for the correspondence clerks to be in a room all together, and here letters are typed, stamped, and despatched; incoming letters are recorded and filed after being dealt with; telegrams are sent off, duplicates being kept; and, where the telephone is not laid on to every department, telephone messages are received and distributed to the officials for whom they are intended. The duplicating apparatus, mimeograph or multigraph, will be kept in this correspondence department, and all circulars for the advertising and sales departments will be produced here. In smaller businesses one or two shorthand clerks are shared by the various departments, and the letters are all filed together in one general file.

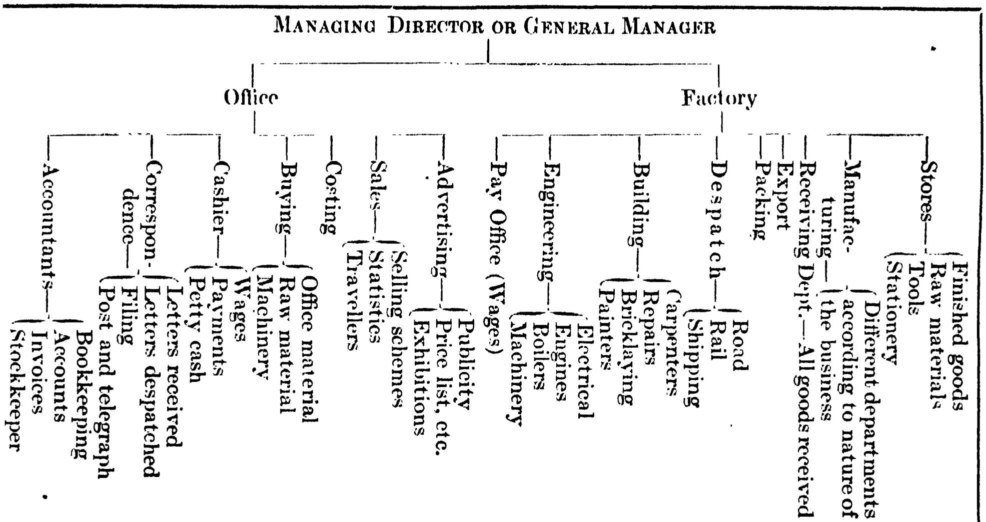


DIAGRAM ILLUSTRATING THE ARRANGEMENT OF DEPARTMENTS IN A BUSINESS

The advertising department is getting more and more important in up-to-date businesses, and it is a very useful rule to let all printed matter, whether it be price-lists, catalogues, labels, circulars, wages-sheets, notepaper, or time-sheets, as well as matters that are more distinctly to be regarded as advertising, pass through the advertising department. That should be the department dealing directly with the printer and block-maker for all matters connected with the business.

Adjoining, or quite close to, the advertising department will be the sales section,

and it is difficult to draw the line between these, for every advertising scheme must of necessity be a selling scheme, and any selling scheme is useless unless it is supported by advertising in some shape or form. Schemes may be conceived and initiated by either the advertising or the sales manager, but they must be developed and worked out by the two in conjunction. The advertising department prepares the literature, engages the staff for a sample distribution scheme, arranges a stand at an exhibition, or organises a Press visit to the works, and the sales department works the trade and sees that the public are supplied when the demand is created. Final arrangements for any big scheme are usually made by the managers of these two departments in consultation with the managing director.

The accountants and cashiers will be closely connected, and, in a small business, are often in the same room. At the head of the accountants will be a chief accountant, or, if the business is a limited company, a secretary. It will be his duty to supervise all accounts, to see that the bookkeeping is kept up to date, that the costing is carried out scientifically, and that the manufacturing is worked economically, as revealed by the complete accounts.

The accountant is a more important official than he used to be, and he will need to have a great deal of tact, for his duties are delicate, and the heads of the various departments with whom he comes in contact—the advertising manager, the factory manager, and so on—may be inclined to resent any attention he may direct to over-expenditure on their part. While it is necessary that he should keep a careful eye on every department to see that there is proper economy, he must, of course, "abstain from every appearance of evil," in the sense of seeming to interfere with the duties of others or concerning himself with matters that do not rightly come within his province.

The old-fashioned bookkeeper, who merely kept the books, entered up his accounts in a mechanical way, and took an interest in nothing save the office clock and his weekly salary, is fast disappearing. In his place has arisen the man who has a love of his work for the work's sake, who takes a real delight in figures, who is interested in seeing them work themselves out to completion, and who finds bookkeeping and accountancy as fascinating as the work of an engineer or a doctor or an architect.

It will be the accountant's duty in a properly organised office to work out a thoroughly efficient system of checking all expenditure. In this he must, of course, be guided by the nature of the business he is engaged in, and the character of the different departments. He will see that competitive estimates are obtained by the buyers, and if the lowest is not accepted he will want to know what considerations led to the paying of a higher price—whether it was the better quality of the goods, the greater reliability and solvency of the firm concerned, or the superior promptitude with which the goods could be delivered. For all petty cash paid out, whether in large or small sums, he will require duly receipted vouchers; for all cheques paid, accounts and receipts must be placed before him; and the postage-stamp account, which is such a large item in some businesses, will have to be placed on a properly organised basis so that there are checks on the number of letters posted and the daily balance of stamps. The live accountant will see that the post-book is checked every day.

The preparation of the half-yearly or yearly balance-sheet will be a duty of the accountant, and he will also prepare from time to time for the benefit of his principals an interim balance-sheet. As all the accounts of the firm will be under the direct supervision of the accountant, it is essential that the bookkeepers, invoice clerks, costing clerks, and so on be easily accessible to him. His office should really be a smaller room opening out of their larger one, or, if they are divided up into various offices, the accountant's room should be fairly central to theirs. The cashier's department must also be handy to the accountant's, owing to the frequent necessary intercourse between them.

An important subordinate in the accountant's department will be the stock-keeper, the clerk who keeps account of all the stores in hand, and checks the outgoings. The old system was to have a stock-book, but under the modern method everything is recorded on the card-index system, and it is doubtful if in any other department of the office organisation, even in the statistical section, the card index is of such value and so far supersedes the old system.

For each particular kind of stock there is a card divided into two columns, each column being ruled according to the requirements. On the left-hand side is the date of each order, the quotation accepted, the date the goods were received, and the total quantity delivered. Each new order and consignment of this particular kind of stock is entered in turn until the column is full, when the card is turned over and the entries continued on the other side in the left-hand column. On the right-hand column, or section, of each card, the various requisitions of goods and the dates on which they were handed over to the department requiring them are entered, and in this way, by comparing the quantities of stores received, as set forth on the left-hand column, and the quantities handed out to the departments for use as set forth on the right, the exact stock at any particular moment, and the quantities on order, can be seen at a glance, or ascertained without delay.

The storekeeper in the warehouse will, of course, hand out no stores except upon the duly authorised order-form, signed by whoever may be made responsible for requisitioning materials in each department; and these authorisations he will file, and hand over at the close of each day to the stockkeeper in the office, who, in his turn, will check them and enter up his cards from them.

The costing department is, of course, an exceedingly important one, and as the figures here worked out and the information collected and filed are very confidential, the office must be quite shut off from the other offices, and entrance prohibited to all but those specially authorised. In the costing department are concentrated many of the trade secrets which would be of great value to competitors, and which must therefore be guarded most jealously. The office is often kept fastened on the inside, so that it is necessary to knock or ring in order to gain admission. This question of privacy is an important one, for, unless precautions are taken, much confidential information overheard during telephone conversations, or casually gleaned from letters and other documents left lying about, is liable to leak out and become common property, owing to the wilful or unguarded conversation of junior clerks and office boys. One of the secrets of success which every youth and young man in business should take well to heart is, as the Americans say, to "keep your tongue between your teeth"—that is, to know when and how to be silent.

The cashier's office is, of course, another room that must not be a kind of common highway in the general office. It is here that any cash not paid into the bank, including the balance of petty cash each night, will be safely housed in a steel safe, and locked up each evening when the office closes. If the accountant has no steel safe or strong-room of his own, he will place his books in the cashier's safe at night, so that they may be protected in case of fire.

An important part of the organisation of any office is the planning out of a system of automatic checking which shall ensure the certain and almost instant discovery of mistakes and delinquencies in books and accounts. Clerks should check one another's work, but no two clerks should regularly and continuously check each other. Thus, A should not always check B, and B, A; nor should C continually check D, and D, C; but A should at various times check B, C, and D; B should check A, C, and D, and so on. In this way anything like possible collusion is avoided. The system should be such that the work and the books of all, high and low alike, are automatically checked, but the particular method to be adopted is rather a matter of bookkeeping than of office organisation.

The organisation of the office should, of course, include the proper discipline of the staff. As far as possible, regular office-hours should be kept by all, but more important than keeping exactly to the regular hours is the completion each day of that particular day's work. No letters should be left over for the morrow, but everything should be dealt with on its own day. This avoids the accumulation and delay of correspondence which is the curse of all good business. It should be distinctly understood by each clerk that the day's work must be finished before he leaves, and every attempt should be made to enthuse the clerks and other workers so that they do this, not because it is the rule, but because they have a keen interest in the work for its own sake.

To this end, a periodical talk by the managing director or other chief is useful in making each junior man feel that he is an essential part of the business. These talks need not be given at formal gatherings. The various members could be

summoned to the general office half an hour before closing time, and the value of such periodical gatherings in inspiring the workers is quite as great as are the travellers' conferences now held so generally by all really live firms.

Anything in the sense of "skylarking" in the office must be at once suppressed, for nothing is more demoralising to the staff, or undermines the organisation so insidiously. Discipline must be maintained. If the hour for lunch is from one to two o'clock, then this time should be strictly observed by the clerks, none of whom should be allowed to leave before one, or remain away after two without special permission. Each man should have his duties carefully defined, and the office boys should know exactly under whose authority they come. At the same time, they must not be allowed to presume upon the fact that they are to take orders only from certain individuals, and as a result be rude to other members of the staff who are not authorised to give them instructions.

Pains should be taken to see that every man keeps his desk tidy, and that no litter is allowed to lie about the office; that doors are shut by those who pass through them; that pens, ink, and so on are put away at the end of the day, and that no books are permitted to remain out of the safe through the night. The better organised in this way the office is - in small details as well as in the larger schemes—the better work will the men do, and the more seriously will they take their tasks. Anything ordered in a mere martinet spirit has the opposite effect; but it is astonishing how a strict disciplinarian who is thoroughly enthusiastic can make all who work under him catch something of his own enthusiasm.

In selecting the office staff some regular system should be followed, and it is essential that the man engaging new employees should be able to read character, to get some idea from a man's manner and appearance of his disposition and ability; to appraise his value within a little as the result of a single interview. To get the best work out of the staff there must be some systematic scheme of promotion by merit, and every man who enters the office should have an opportunity of showing his capabilities and possibilities. Individuality should be cultivated and encouraged in the sense that a man's particular gifts should be afforded full scope, but the spirit that must be infused is that which elevates the firm as a firm to the first place. The staff, including heads of departments, should be encouraged and unconsciously led to talk of "we" and not of "I." The business life should be lived not for the individual but for the firm as a whole, and every man must be led to regard his own firm as the greatest in its line. Enthusiasm is the keynote of success, and in the properly organised office this spirit will impart itself to every member of the staff, however unimportant he may be, and show itself in enthusiastic loyalty.

The true spirit can never be infused by a manager who holds himself aloof from his subordinates. The chief should always talk *with* his staff and not *at* them. Praise should be given where deserved as well as blame, and every pill should be sugared. It is amazing how a little judicious praise will tone up the quality of a man's work, and by doing so add greatly to the emulation of others. At the same time there must be no jocular familiarity of the heads with their subordinates. Weak men go to one extreme or the other, but the strong and able man knows exactly how to blend discipline and comradeship so that while he inspires the confidence and friendship of his men, at the same time he prevents the familiarity which breeds contempt.

Promotion and increases of salary should always be won by merit. Through the year the heads should keep their eyes open, and they will soon see who are the keen, energetic men, and who are the lazy.

In many large firms one of the conditions of promotion is that junior members of the staff should attend evening continuation classes; and although this may at first mention seem outside office organisation, it is becoming an essential part of the discipline in many up-to-date businesses.

There should never be any work in an office that can be done by only one particular man. Every man, high or low, should have his understudy, and no man, however successful, should be allowed to regard himself as indispensable.

For everything there is a best way, and the keen manager will see to it that in every department of the office, and in every branch of its work, the best possible way is discovered and followed.

CHARLES RAY

Sensations of Heat untrustworthy. Temperature and its Measurement. The Various Thermometric Scales.

THE SCIENCE OF HEAT

By way of a preliminary to our study of heat, we must first of all rid ourselves of the confusion into which our own sensations lead us. When we speak or think of heat, there is always involved an idea derived from a group of sensations with which we are all familiar; and so the first thing we must do is to distinguish between what psychologists call the *subjective* and *objective* aspects of our study. Subjectively, we are familiar with sensations of heat and of cold, but directly we attempt to analyse the facts we observe that these sensations are in ourselves, and are due to external causes, which can be sharply distinguished from the sensations directly we remember that the same external cause may appear hot to one hand and cold to another. This may easily be proved. If we hold one hand in very cold water for a few minutes, and the other at the same time in very hot water, and then plunge the two hands into a basin of lukewarm water, one and the same objective cause will excite a sense of heat in the one hand and of cold in the other. This simple experiment suffices to demonstrate that it will not do to mix up psychology and physics in our discussion of heat.

Heat and Sensation. Another trick which our sensations play us will serve to teach us an important fact. We pick up the poker on a cold morning, and it feels cold: we transfer our hand to our coat and it feels warm. Yet both are probably at the same temperature. A suitable thermometer or heat measurer would contradict the opinion of our hand. The explanation lies in the fact that, as we shall see, different bodies vary widely in their power of conducting heat. The wool of our coat is a bad conductor; it removes little heat from our hand, and so does not give us an impression of cold. The metal poker, however, which is at the same temperature as our coat, or, indeed, being near the fire, may be hotter, has the physical property of conducting heat very well. So much heat does it conduct away from our hand that the sensitive nerves appreciate the loss, and we declare the poker to be cold. Thus our senses at least can give us some idea of what is meant by the conduction of heat. But now we dismiss the psychological aspect of the subject, and must conceive of heat as an external fact, the character of which is not in the smallest degree indicated by our sensations.

Temperature. When one thing is hotter than another—that is to say, when it is really hotter, not when it merely feels hotter—we say that it is at a higher temperature, and we measure the difference of temperature by means of the thermometer. But we are not entitled to say that when one object is hotter than another it contains more of that thing called heat. The temperature of the body is not a fact that depends upon the amount of heat that it contains, and can never be used—except under conditions defined below—as an index or guide to the amount of heat in any body. What, then, is temperature? We can best define it by observing its consequences. When one thing is hotter than another, the observed fact is that the hotter body tends to communicate part of its heat to the colder, so that the two tend to approximate to the same temperature. It does not at all follow that there is more heat in the hotter body than in the colder. In the first place, the hotter body may be very small and contain little matter; whereas the cold body may be very large and contain a quantity of matter.

The Flow of Heat. The only way in which to define temperature is to compare it to the idea of level in liquids. We know that, quite apart from the amount of water in question, if we join two vessels or reservoirs containing water, the one being at a higher level than the other, the water will certainly flow from the higher to the lower. If they are at the same level, the water will flow in neither direction, though the difference in the amount of water in the two reservoirs may be as great as the difference in the amount of heat in the case of our finger and the ocean. Therefore, we must define temperature as that state of a body which determines its power to communicate heat to or receive heat from another body.

Amount of Heat. Of course we must not think that temperature has no relation to the amount of heat in a body. If we take a fixed quantity by weight—that is to say, more strictly speaking, a fixed mass of a given substance—then the temperature of that mass will be an index to the amount of heat it contains. The more heat we put into it, the hotter it will become. So far as differences in mass are concerned, it is evident that temperature and amount of heat do not vary together. There will plainly be more heat in a ton of lead at 30° C. than in a pound of lead at 31° C. But the remarkable fact is that different kinds of matter vary profoundly in the amount of heat they contain while exhibiting the same temperature. If, for instance, we take equal masses of water and of mercury, starting with both at the same temperature, and proceed to raise them both to the same extent, say 10° C., we find that we actually require to put about 30 times more heat into the water than into the mercury. Yet at the end of the process they are both at the same temperature, both having started at the same temperature, and we are dealing with

an equal quantity of matter in each case. The difference between the water and the mercury is expressed in the term *specific heat*, and we shall afterwards have to consider it carefully.

The Thermometer. The thermometer is an instrument which enables us to measure temperature, but we now understand that it does not enable us to measure *amount of heat* except by the comparison of the various temperatures of a given mass of a given substance. In the most familiar kind of thermometer, the temperature is measured by the expansion and contraction of mercury. This substance, like nearly all others, expands when it is heated and contracts when it is cooled. The mercury thermometer consists of a fine, hair-like tube with a bulb at one end, the bulb and part of the tube being filled with mercury. When the thermometer is made, the mercury is boiled in the tube so as to carry away all the air, and then the upper end of the tube is sealed. The smaller the tube, the more sensitive is the instrument, the most sensitive kind of thermometer with which most people are familiar being the clinical thermometer.

Cent	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.
—17·7 ..	0	7 ..	44·6	31 ..	87·8	55 ..	131	78 ..	172·4
—16 ..	3·2	8 ..	46·4	32 ..	89·6	56 ..	132·8	79 ..	174·2
—15 ..	5	9 ..	48·2	33 ..	91·4	57 ..	134·6	80 ..	176
- 14 ..	6·8	10 ..	50	34 ..	93·2	58 ..	136·4	81 ..	177·8
- 13 ..	8·6	11 ..	51·8	35 ..	95	59 ..	138·2	82 ..	179·6
12 ..	10·4	12 ..	53·6	36 ..	96·8	60 ..	140	83 ..	181·4
—11 ..	12·2	13 ..	55·4	37 ..	98·6	61 ..	141·8	84 ..	183·2
—10 ..	14	14 ..	57·2	38 ..	100·4	62 ..	143·6	85 ..	185
— 9 ..	15·8	15 ..	59	39 ..	102·2	63 ..	145·4	86 ..	186·8
— 8 ..	17·6	16 ..	60·8	40 ..	104	64 ..	147·2	87 ..	188·6
— 7 ..	19·4	17 ..	62 6	41 ..	105·8	65 ..	149	88 ..	190·4
— 6 ..	21·2	18 ..	64·4	42 ..	107·6	66 ..	150·8	89 ..	192·2
— 5 ..	23	19 ..	66·2	43 ..	109·4	67 ..	152·6	90 ..	194
— 4 ..	24·8	20 ..	68	44 ..	111·2	68 ..	154·4	91 ..	195·8
— 3 ..	26·6	21 ..	69·8	45 ..	113	69 ..	156·2	92 ..	197·6
— 2 ..	28·4	22 ..	71·6	46 ..	111·8	70 ..	158	93 ..	199·4
— 1 ..	30·2	23 ..	73·4	47 ..	116·6	71 ..	159·8	94 ..	201·2
0 ..	32	24 ..	75·2	48 ..	118·4	72 ..	161·6	95 ..	203·
1 ..	33·8	25 ..	77	49 ..	120 2	73 ..	163·4	96 ..	204·8
2 ..	35·6	26 ..	78·8	50 ..	122	74 ..	165·2	97 ..	206·6
3 ..	37·4	27 ..	80·6	51 ..	123·8	75 ..	167	98 ..	208·4
4 ..	39.2	28 ..	82·4	52 ..	125·6	76 ..	168·8	99 ..	210 2
5 ..	41	29 ..	84·2	53 ..	127 4	77 ..	170·6	100 ..	212
6 ..	42 8	30 ..	86	54 ..	129·2				

Three Scales of Temperature. In order to compare one temperature with another, it is necessary to have some sort of scale, and there are many such in existence. Here we may mention three, with the preliminary statement that they are all arbitrary and bad. Until quite recently the choice between them was merely one of convenience; but they may now all be superseded because we are in possession of a scale of temperature which depends, not upon the arbitrary selection of any substance such as water or mercury, but upon our understanding of the natural lowest limit of possible temperature.

The most familiar and oldest scale is that invented by Fahrenheit (1686-1736). He did his best to obtain the lowest temperature possible, which was that of a mixture of pounded ice and salt. He called this temperature 0°, and the temperature of water boiling at ordinary pressure 212°, the freezing point of water on this scale being 32°. Fahrenheit rendered great services to physics, and honour is due to his memory, but at the present day his scale can claim no advantages whatever, in spite of the fact that it is still constantly used in this country, though abandoned elsewhere.

The Centigrade scale, which has many advantages over that of Fahrenheit, is so named because the interval between the freezing point and the boiling point of water is divided into a hundred degrees. According to this scale, the zero is the freezing point of water and 100° is its boiling point. This scale is not very much younger than Fahrenheit's, and is now universally used in science, and for all other purposes as well, in France and many other countries. It may be adapted for the purposes of the *absolute scale of temperature*, which has superseded all the others in modern scientific inquiry.

The Réaumur scale, invented by Réaumur (1683-1757), has been largely used in Germany. It agrees with the Centigrade in that its zero is the freezing point of water, but the interval between this and the boiling point of water is divided into eighty degrees instead of one hundred degrees.

Conversion of the Scales. Until the Fahrenheit and Réaumur scales go completely out of use, as they sooner or later certainly must, it is occasionally necessary for convenience to convert a figure of one scale into the corresponding figure of another. This, of course, is a mere matter of arithmetic, no physical truth being involved, and so we need give the methods only very briefly. In the first place, notice that 5° Centigrade is the equivalent of 9° Fahrenheit, and either of these is equivalent to 4° Réaumur. Supposing we desire to convert a Fahrenheit statement into a Centigrade, it is necessary, first of all, to deduct 32, then to multiply the result by five, and then divide by nine. In order to convert it into degrees Réaumur, it is similarly necessary, and for equally obvious reasons, to deduct 32, the result being multiplied by four (instead of five as in the last case) and divided by nine. On the contrary, if we require to convert degrees Centigrade into the Fahrenheit scale, it is necessary to multiply by nine, divide by five, and add 32 to the result; and if we are converting degrees Réaumur, the process is exactly the same, except, of course, that we divide by four instead of five.

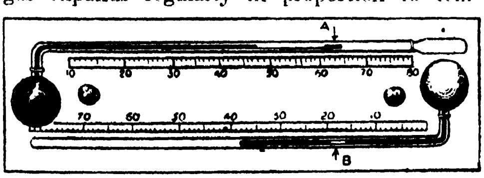
For convenience of reference we give on this page a table prepared by Messrs. Negretti and Zambra, showing the Fahrenheit equivalents of the Centigrade scale from Fahrenheit zero to the boiling point of water.

Maximum and Minimum Thermometers. So far as the thermometer is concerned, the particular scale that is used is of small importance. But sometimes it is of convenience to have some arrangement by which the highest or

lowest points of temperature recorded may be indicated in such a way that anyone coming afterwards may see what they were. For instance, a small index of iron or glass may be placed inside the thermometer, so that it is pushed up by the advancing mercury, but is left behind when the mercury falls. If the index be made of iron it can be pulled down again by means of a small magnet. The minimum thermometer is filled with alcohol instead of mercury, and as the alcohol falls it pulls the index down with it in virtue of surface tension. When the temperature rises the alcohol flows past the index. If two such thermometers be mounted on one board, we can see at a moment what were the limits of the variation of temperature.

Another form of the maximum thermometer is the clinical thermometer. It contains no index, but at one point the tube is very much constricted, so that, when the thermometer is removed from the patient, the cohesion of the mercury is not enough to keep it together at this point; hence the column of mercury breaks, and the highest point recorded by the mercury is retained. In order to obtain a fresh reading, it is, of course, necessary to re-establish the continuity of the mercury, and this may be done by jerking the thermometer so that part of the broken column flows past the narrowest place and rejoins the rest.

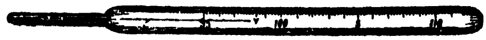
A Better Thermometer. It is an easy matter to agree on a scale of temperature, and to mark its divisions upon the glass tube, but how are we to be certain that the mercury, or, indeed, any other liquid that may be employed, such as alcohol, expands in a regular fashion? Provided that it does so, equal elongations of the column will certainly indicate equal differences of temperature. But when we come to look into the matter we find that liquids do not follow this simple rule, and so none of our ordinary thermometers can be regarded as absolutely accurate. If, however, instead of taking a liquid we take a gas, we find not only that any gas expands regularly in proportion to tem-



MAXIMUM AND MINIMUM THERMOMETERS
A, Maximum Index B. Minimum Index

perature, but also that the various gases agree with one another in this respect and can safely be compared. Hence we have the air thermometer, which depends upon the fact that the volume of a given quantity of gas increases uniformly as the temperature rises, provided the pressure be constant, in accordance with Boyle's law. This is true of gases, liquids, and solids. But gases are much more satisfactory to study, because not only is their expansion much more marked, but they expand with absolute regularity, and the ratio of expansion is almost the same in the case of all gases. The law of the expansion of gases is of the utmost importance. The volume of a gas increases for each degree of rise in temperature by a constant fraction of its volume at freezing point, this being $\frac{1}{273}$ for the Centigrade degree, assuming, of course, that the pressure remains constant.

The Absolute Air Thermometer. The *absolute air thermometer* consists of a long glass tube, closed at one end and containing a long



CLINICAL THERMOMETER

column of air which is closed by a drop of mercury. This behaves as any air thermometer would do, the expansion and contraction of the air in the tube changing the position of the drop of mercury. This thermometer is graduated on the absolute scale, in correspondence with the law already quoted. The freezing point of water, instead of being called 0° as it is in the Centigrade scale, is marked 273° C. absolute, and the boiling point, instead of being marked 100°, is marked 373° C. absolute Its zero is the *absolute zero*—that is to say, while we retain the size of the Centigrade degree, we alter the names in accordance with the theory that the fraction $\frac{1}{273}$ is of real significance. If, now, we consider the case of the air in this thermometer, we are able to lay down the proposition that, the pressure being constant, its volume is proportional to its absolute temperature. In other words, the volume of any gas at constant pressure varies as its absolute temperature. If we combine this law, sometimes called Gay-Lussac's law and sometimes Charles's law, with Boyle's law, we reach the following law, true of all gases except in the neighbourhood of the temperature at which they tend to liquefy: *The product of the volume and pressure of any gas is proportional to its absolute temperature.*

The Absolute Scale. As was hinted in a previous chapter, the absolute scale of temperature assumes that heat is a definite something of which there may be more or less in a body, and which may be abstracted from a body until we ultimately reach a point when there is no more heat left. Such a body would be absolutely cold, and its temperature would be the *absolute zero.* No such temperature has yet been attained, and it is very doubtful whether it can be attained by any possible device, though Professor Onnes, a few years ago, attained within three or four degrees of it. It is plain that if our idea of heat is correct, there must be an absolute zero. The question is whether we have any indication to guide us to the point where this absolute zero is to be found. This point was determined by Lord Kelvin, to whom we owe the scale of absolute temperature, in 1848, and was reached by means of thermodynamic considerations, a term which we shall soon explain. But the reader will have already perceived that the point named—that is to say, −273° C. (on the *ordinary* scale)—is the point suggested by the law of the expansion of a gas. When we come to consider thermodynamics, we shall return to this subject. We must go on to consider the expansion that heat causes in bodies other than gases. C. W. SALEEBY

Intercepting Chambers. Manholes. Iron Drainage. Stable Drains. General Arrangement of Drains.

THE PRACTICE OF DRAIN LAYING

Laying Drains. We have now to consider how the various fittings already described are combined into a complete drainage system, and it will be convenient to look at the work of drain-laying before referring to the preparation of a drainage plan. For the moment, we shall assume the existence of such a plan on which the drains and all fittings are shown and on which the levels of the sewer and the inclination of the drains are fixed.

The laying of the drains is often deferred till other work in the building is far advanced, but it involves a large amount of excavators' work, and will now be described. The first operation is the excavation and strutting of the trenches, which in most cases are made of the minimum width in which a man can work. The bottom is carefully levelled to the falls shown upon the drawings—not stepped as in the case of trenches for walls—and where it is required a layer of Portland cement concrete is spread evenly over the bottom of the trench. Concrete is always desirable, but some local authorities do not insist upon it under rain-water pipes. The concrete should be 6 in. deep and should extend for a width of 6 in. beyond the outer face of the pipe on each side. The lower 6 in. of the trench should be excavated to the exact width required for the concrete, even if a greater width for working be necessary higher up. The concrete slabs on which the manholes are to be built are also put in. They are usually 9 or 12 in. thick and extend beyond the outer face of the manhole for about 9 in on all sides. Layers of concrete are also required under traps and gullies.

Connection with Sewer. The actual connection with the public sewer, for which purpose junctions are often built into the sewer, is usually made by the local authority, who bring up the branch drain to the point where the private property abuts on the road. The laying of a drain begins from the lower end, and the spigot end of a pipe should always be the lower. Every drain should be laid in a perfectly straight line from manhole to manhole, or from any gully or trap to the manhole. The fall in the same distance should also be absolutely uniform. The reason for this is, that in a drain so laid it is possible, with the help of a mirror, to see through it from manhole to manhole and to detect at once the position of any obstruction.

The illustration [39] shows a plan of a town house of considerable size and the method of draining it. Fig. 40 shows the plan of a large country house. In the latter there may be a considerable length of drain beyond that shown, so as to carry the system to a sewer or to the point where the sewage is to be dealt with, but the construction will be similar, lampholes and manholes being provided alternately at intervals.

Forming the Intercepting Chamber Floor [41]. The footings and wall of the chamber must be raised to the levels at which the drains enter it. The intercepting trap is fixed at its proper level standing on a bed of concrete and set in concrete. The necessary channels are selected from the list of the maker whose goods are specified, and are first put together dry, to see that they fit properly the positions for which they are intended, and are then laid on fine concrete, the joints being left free till they have been very carefully made in cement. The main channel is jointed to the upper end of the trap, and if this channel can be obtained in one length, the upper, or socket, end receives the main drain from the building. In a large manhole the channel may be in two or more lengths, jointed. The channels from the branch drains, if any be required, are then fixed. The bottom or invert of each discharges into the main channel, and the upper end of each is jointed to the branch pipe. When these are fixed, fine concrete is filled in between the channels, care being taken not to break the joints, and is banked up from the edges of the channels to the side of the chamber. In the case of a chamber receiving several branch drains at the sides, the banking must be curved to conform to the various branch channels, and often forms a somewhat narrow tongue between two curved channels. All this work requires great care, as the slightest flaw may allow the escape of water and result in the chamber being condemned. This banking is finally finished with a smooth trowelled face with Portland cement mixed with a little sand.

In order to avoid the complicated work of forming the bottom of a manhole as described, manufacturers now provide channels and junctions in one piece, suited to a variety of combinations. These may be utilised to form the bottoms of manholes. Some of these are also provided with covers [37, 38] to close the channels and prevent any possibility of the solid matter carried in the sewage being washed out of the channel by a sudden flush, deposited on the banks, and then left to decompose. Even when this is not provided, the fact that the bottom is in one solid piece, without a multiplicity of joints, is an advantage, but the fact of its being so may sometimes interfere with the nice adjustment of the drainpipe to the channel, possible in the ordinary method.

Building the Manholes. When the channels are set they are protected with boards, and the manhole or chamber is built up by the bricklayer to the level of the ground. If it is deep, he builds into one side or angle a series of iron steps or bars, called *climbing irons*, to render the bottom of the manhole accessible when necessary for inspecting or cleansing the drains. The size and form of a manhole depends on the number of drains which enter it, but, except in the case of a very shallow one, it should not be less than 2 ft. 6 in. in length or width, or it is difficult to use cleaning rods. The top may be contracted by means of oversailing courses [see BRICKLAYER], or it may be covered with a single slab of stone [Fig. 35, page 1001], which is perforated and rebated [see MASON] to receive the *manhole cover*.

The Manhole Cover. The manhole cover consists of an iron frame (which should be galvanised) with a flange, which is bedded in cement on the brickwork top or in the rebate of the stone. There is a groove running all round the frame, and the top or cover has on its under side a flange which fits into the groove and seals the manhole. When closed, this groove may have sand or water placed in it to make an air-tight joint, but the best method is to make a joint with Russian tallow, though other compositions are used. The object of making the cover air-tight is to prevent the escape of sewer gas, and for additional security double covers are often arranged for and should be used wherever a manhole has to be constructed within a building.

The cover, usually loose, is in some cases screwed to the frame at the angles; but if this is done, the holes must not be placed inside the frame, or, in the event of one of the screws being left out a free passage for sewer gas is provided. The top should be secured to a lug or flange outside the grooved channel. The walls of the manhole are often rendered in Portland cement [see PLASTERER] for the lower part or to the full extent of their height. In the best class of work, interiors of manholes are often built with glazed bricks.

Fresh-air Inlet. Every intercepting chamber must have a fresh-air inlet. For this, an ordinary drainpipe is taken into it near the top, which should be of the same diameter as the drain passing through it. This is taken to a selected point and connected with a vertical iron shaft, finished with a box-shaped head [Fig. 36, page 1001]; in the front of this one or more diaphragms, formed of thin sheets of mica and hinged at the top, are placed, so that, in the event of there being any pressure of air from the inside, they will close the orifice and prevent its egress, but will readily open to admit fresh air to the chamber and thence to the drain. This apparatus requires periodical attention otherwise the diaphragms are liable to become fixed, and thus permit the egress of sewer gas.

The ordinary *inspection chamber* [42] only differs from the intercepting chamber in that it has no trap at the outlet and no fresh-air inlet, otherwise it is constructed in the same manner—a cleaning pipe replacing the intercepting trap.

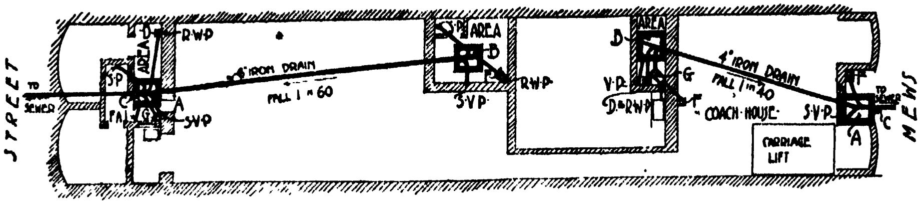
Where a chamber is only required to allow of change of direction in the drain [43, 44], it may be kept smaller but is in other respects similar.

Lampholes. Lampholes [45] are useful in long, straight runs of drainpipes which receive no branch drains, enabling inspection chambers to be built further apart than would otherwise be the case. They are formed with ordinary drainpipes placed vertically over the drain, connected to it with a junction, which in this case must be a right-angled junction, and extending up to just below the ground level. The top is securely closed with a stopper, and may be buried two or three inches under the ground and marked, or—which is a better practice—terminate in a small chamber with a manhole cover. The object of this pipe is to permit of a lamp or candle being lowered to the level of the drain, so that it may be examined from the manhole above or below it in case of an obstruction.

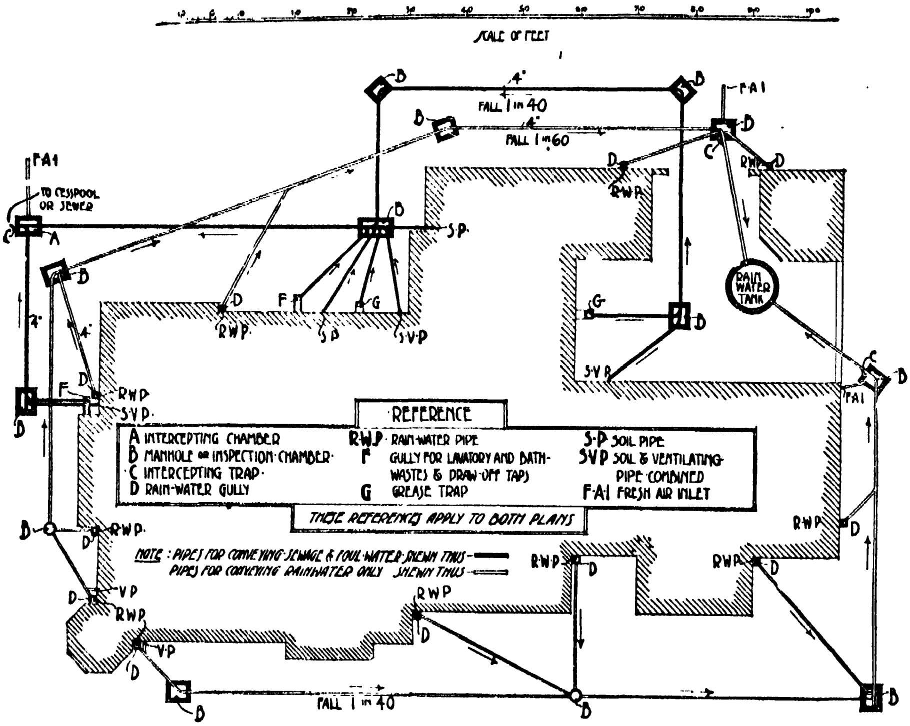
Laying the Pipes. The drain from the intercepting chamber to the next manhole or to a gully, soil-pipe, or ventilating pipe is usually put together dry and carefully levelled. In very good work special chairs of earthenware are used to raise the pipes about 2 or 3 in. from the concrete bed to allow of the joints being made all round, but this is often done with pieces of brick or stone. The ordinary joint is made with Portland cement gauged with as little sand as possible. The socket of one pipe is coated with the material, and also the spigot end of the next pipe, and the latter is then thrust into the socket, care being taken to see that it is properly centred and goes well home and that the joint is at all parts well filled with cement. The joint is afterwards carefully smoothed externally with a trowel and finished with a splayed surface or collar [17, 18, page 1001]. The inner face of the joint is also carefully cleaned, the workman thrusting his arm into the pipe and wiping off any cement which may be forced up between spigot and socket of the two pipes, and which, if allowed to remain, would obstruct the flow of the sewage.

A *badger* is sometimes employed in this operation. It consists of a block of wood smaller than the pipe, but with a rubber edge and a wire handle. It is placed below the joint before it is made, and afterwards withdrawn, bringing away any cement. Every pipe should be separately laid so that this operation may take place. If two pipes are joined before being laid in the trench, the total length will be found too great to permit of it. Joints between pipes and channels or gullies are similarly made, and in any case where an inspection or cleaning eye is introduced the run of the pipes from this point to the next manhole should be perfectly straight and the fall perfectly even, as described, between manholes.

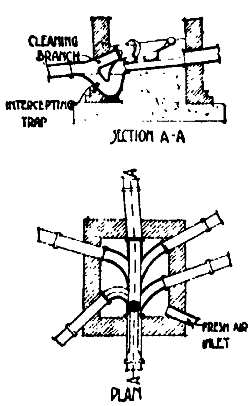
Special Joints. Other forms of joints are used between pipes. One of the most usual



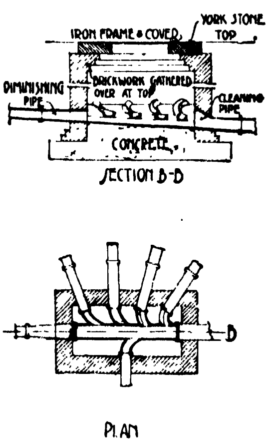
39. Block Plan of a large Town House and Stables, showing Drainage.



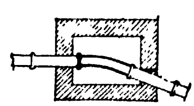
40. Block Plan of a large Country House and Offices, showing Drainage.



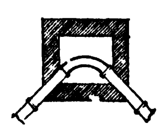
. Intercepting Chamber.



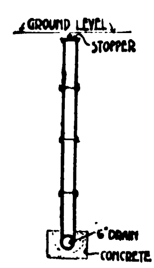
42. Inspection Chamber.



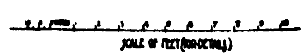
43. Small Chamber for Bends without Branch Drains.



44. Small Chamber for Bends without Branch Drains.



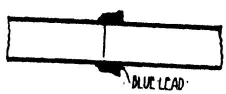
45. Lamphole.



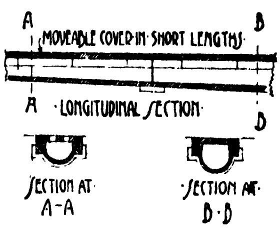
39-45. PLANS FOR GENERAL DRAINAGE SCHEMES AND DETAILED SECTIONS

is known as Stanford's joint [19, page 1001], the patent for which has expired. In this joint the socket is lined with a composition formed with 1 part of clean sharp sand, 1 part of boiled tar, and $1\frac{1}{2}$ parts of sulphur. The surface is slightly bevelled, the spigot has a band of the same composition slightly rounded, and the two when brought together form a close joint which ensures that the pipes are truly centred. The surface of the joint is smeared with tallow before the pipes are fitted, and the spigot end must be driven well home to ensure a close internal joint. The outer edge of the joint is often finished with a cement collar. Another form of joint has the composition cast on in the form of a screw, the pipes being screwed together in fixing. A thin layer of cement composition is used with this joint.

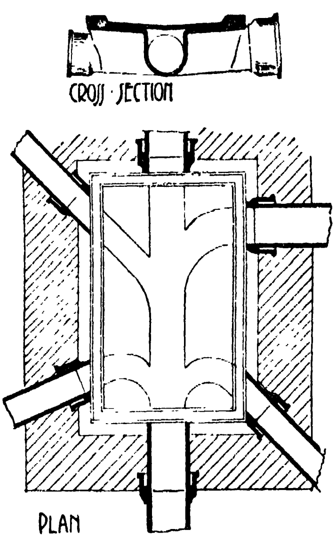
A special joint for pipes with a deep socket is formed with two separate rings of composition with a clear space between. After the pipes are put together this space is filled with liquid cement from a hole at the top formed for the purpose. This forms a strong water-tight joint. Where a drainpipe is to be connected with a vertical soil or ventilating pipe—a connection which must always be direct, without any trap or gully—a bend must be used to connect the inclined drain and the vertical pipe. The end of the pipe, if of iron, is inserted into the socket of the bend and the joint made in cement. If the pipe is a lead one the end has a ring of brass, termed a *sleeve* or *ferrule*, fixed on its outer surface before the joint is made [see PLUMBER].



46. JOINT FOR IRON PIPES.



48. SECTION OF AN IRON STABLE CHANNEL.



47. IRON MANHOLE WITH SIDE INLET.

When any section of a drain is completed it should be at once tested as hereafter described. If every joint is found to be absolutely sound and no leakage occurs, concrete may be filled in around the pipes very carefully. Each joint must be examined, the upper surface by the eye, the lower surface by placing the hand below to see if there is any moisture exuding from the joint. The concrete is filled in under the pipes and the chairs or bricks used to raise the pipes are left in position. The concrete is in most cases filled in till the crown of the pipe is covered with 6 in. of it. Great care must be exercised in depositing the concrete, as any serious jar may break one of the joints, and when re-tested after the concrete has set the length may not hold water and have to be taken up and re-laid. The trench above the concrete should not be filled in till this re-testing has been done, for should a defect be found the labour will be thrown away.

Iron Drainage Fittings. In addition to the various forms of earthenware goods hitherto described, cast iron is employed a good deal. In any drainage scheme which involves carrying a drain under a building, the local authorities usually enforce the use of iron pipes of heavy quality for such parts of the work as pass under the buildings.

Iron pipes are described by the weight in lb. per yard run. The following weights are usual for house drains: 4 in., 54 lb.; 5 in., 72 lb.; 6 in., 91 lb. The pipes used for this purpose are cast with deep sockets at one end, and a small projecting bead at the other. They are made in longer lengths than stoneware pipes, and are usually 3, 6, 9, or 12 ft. long. The iron drain should extend from manhole to manhole, to avoid joining them with stoneware pipes, and the joints are made by inserting in the sockets of each pipe a ring of tarred yarn, then running in "blue" lead, so called to distinguish it from white or red lead. Blue lead is melted and poured into the joint, and afterwards caulked or hammered [46].

It is becoming increasingly common to use other fittings of iron, and to carry out entire systems of iron drainage. For this purpose not only pipes, but all the parts and fittings already described as of stoneware are now also made in cast iron.

Makers now manufacture intercepting and inspecting manholes cast in one piece. These consist of shallow iron frames or boxes [47] within which the channels are formed, and outside which the various sockets for receiving the main and the branch drains are cast in at the required angle. An outlet or spigot end is also cast on for jointing to the drain below. The channels may be half round, or they may be extra deep, equal in depth to the diameter of the pipe. These

chambers are stocked in a great variety of forms to suit various sizes of drains, and fitted with branches of various sizes and at various angles. Any combination not stocked can usually be supplied with little delay.

The manhole and all its branches must be set out, and the angles at which they enter measured, before the manhole is selected or ordered. When this is done, no difficulty should arise in fitting up. The great advantage of such a manhole is that, being in one piece, there is no possibility, if the casting is sound, of a leak within the manhole itself, and it is provided with a top resembling an ordinary manhole cover, fitting into a groove and secured into position, which renders the manhole both gas and water tight. There is no possibility, therefore, of sewage overflowing the channels and decomposing, as in an ordinary manhole. Such a manhole, including the cover, is only a few inches deep, and must be placed within a chamber for easy access, but the chamber need not be constructed with the same care as is necessary when an open drain passes through it.

The advantage a complete system of iron drainage possesses over earthenware is in its greater power to resist the disturbing influences due to settlements, vibration, or any external pressure under which an earthenware pipe might be cracked, and allow leakage. The surface of the iron must be protected from corrosion. This is generally done by a coating of *Dr. Angus Smith's Solution*, which consists of a mixture of coal-tar and pitch, with about 5 per cent. linseed oil, and sometimes a little resin, the whole heated to a temperature of about 300° F. The iron to be treated is plunged into the mixture and left in till it attains the same temperature, then removed, and allowed to cool in a vertical position. The best results are held to be obtained when the iron, before insertion, is heated to a temperature of about 700° F., but this increases the cost. Glass-lined or enamelled iron channels and pipes are used sometimes, but are expensive.

The small size of the manholes used in iron drainage systems, which are in some ways advantageous, have this drawback, that in the event of the outlet being temporarily stopped, owing to the sewer being fully charged, there is very little space in which the water collected by the drain can accumulate, and it will speedily overflow; whereas the large cubic space provided in a deep manhole may, under such circumstances, temporarily accommodate the drainage till the stoppage is removed.

Stable Drainage. Stable drains are of a special character. Within the stable itself they are designed to collect and remove from every stall and loose-box the horses' urine. It is not desirable that the floor surface of the stalls should have any great inclination, nor should channels into which a horse might tread be left open where this can be avoided.

Stoneware channels are liable to breakage, and all such drainage is best executed in cast-iron channels, the depth of which is regularly increased, so that the fall is obtained in the channel itself, while the top is kept at a uniform level, or nearly so, and may be covered with strong perforated cast-iron plates [48]. The channel may, in most cases, be run to the external wall, and discharged into a stable gully placed outside. Where this is not possible, traps, with strong iron covers, may be provided, and an underground iron drain taken outside the building.

The covers to channels and traps are easily removed for cleaning, but cannot be disturbed by the horse. Open iron gutters are also sometimes used. They consist of several small shallow parallel channels with ridges between, which are arranged to give a foothold to the horses. All iron work to be laid in a stable floor must be provided with a roughened surface, to give a foothold. Channels are sometimes formed in concrete, with iron kerbs built in on either side to receive the necessary covers.

General Arrangement of Drainage. The drainage of individual buildings as applied to systems of water-borne sewage, with few exceptions, depends upon the action of gravitation, and in arranging a system of drainage this circumstance must not be lost sight of from the first. Care must be taken to see that the levels of the building or site to be drained are such as to allow of the drainage being taken to the public sewer, or to any other required destination with a sufficient fall to ensure its efficient action. In the case of water not carrying sewage, such as water collecting in foundations, it may, if necessary, be collected into a *sump*, which is a chamber sunk below the level to which the water rises, and in which it collects, and from which it may be pumped up so as to flow into a drain; but even this is undesirable, as it means frequent attention and expense. This system is not applicable to sewage from private buildings, but it is sometimes employed on a large scale in sewerage systems with fair satisfaction.

Detailed Arrangements of Drainage. These vary so greatly under different circumstances that it will be possible only to refer to the general principles involved. The first matter to be determined is the ultimate destination of the sewage or water to be dealt with, and the level of the outfall of the drain. Where the difference of level between the lowest part of a building to be drained and the outfall is ample, it removes what may be a serious difficulty should there not be depth for an adequate fall in the drains.

Self-cleansing Drains. For a drain to be self-cleansing the liquid in it should flow with a velocity of at least 3 ft. per second. The velocity is considerably reduced when the drain is only filled to a small proportion of its capacity, which is the usual condition of domestic drainage, and most local authorities require a sufficient fall to give a velocity of approximately 5 ft. per second when the drain is running half full.

A table of the approximate inclination to which drains must be laid to secure various velocities when flowing *half-full*, and the number of gallons discharged per minute when flowing *full* bore, is given below. It is compiled from tables in Hurst's Architectural Surveyor's Handbook.

Internal Diameter of Pipe.	Inclination.	Velocity in Feet per Second.	Discharge in Gallons per Minute.
2-inch ..	1 in 100	2	16
„ ..	1 in 50	3	24
„ ..	1 in 30	4	33
„ ..	1 in 20	5	40
3-inch ..	1 in 140	2	38
„ ..	1 in 70	3	56
„ ..	1 in 45	4	73
„ ..	1 in 30	5	93
4-inch ..	1 in 200	2	66
„ ..	1 in 100	3	98
„ ..	1 in 55	4	135
„ ..	1 in 40	5	162
6-inch ..	1 in 300	2	150
„ ..	1 in 140	3	226
„ ..	1 in 80	4	305
„ ..	1 in 59	5	370
9-inch ..	1 in 450	2	337
„ ..	1 in 220	3	500
„ ..	1 in 125	4	687
„ ..	1 in 90	5	820

It is not, as a rule, convenient for the invert of the manhole at the head of the drain to be less than 1 ft. 6 in. from the ground level, and the fall being determined and the length of drain set out, the actual levels of the various manholes and of the outlet may be calculated in reference to a fixed datum. When possible, it is desirable to make the fall in the drain follow any general inclination in the surface of the ground, so as to save as much deep digging as possible; but the planning of an efficient drainage system must not be in any way sacrificed to do this. In cases where the sewer is very deep, it is usual to lay out the whole system as far as the intercepting chamber to ordinary falls, and to give the last length of pipe between the syphon trap and the sewer the necessary inclination to make the connection.

Where the depth available is ample, the open channel running through the manhole may be given a sharper fall than the general drain (say, 1 in. in 1 ft.), so that the contents before reaching an intercepting trap may attain extra velocity.

Drains not Self-cleansing. Where the depth between the head of the drain and the outfall is inadequate to give the desired fall, the levels must be worked out very closely, and care taken in planning to make the length of the drain as short as possible. It may be necessary to assist the cleansing of the drain by an *automatic flushing tank* [see PLUMBER] placed at the head of it. Water is allowed to flow into this tank at a regulated speed, and when full it discharges automatically its entire contents rapidly and with high velocity into the drain, thereby scouring it out. The outlet of the tank should be as large as the drain to be flushed, the object being to charge the drain fully. The tank should contain not less than 50 gallons for flushing a 4-in. drain, and the frequency of the flush may be regulated. Tanks with larger capacities may be used, and are necessary for larger drains.

Size of Pipes. The size of drainpipes is regulated by the work they have to do. Where the sewage system is separate the maximum flow can be readily gauged, and, as an example, the regulations of the Board of Education require a 4-in. pipe, unless it is connected to more than ten w.c.'s, in which case it must be 6 in.

If the rainwater is carried by the same pipe there is a liability in times of excessive rainfall for the drain to be choked with water if it is inadequate to carry it off. It is necessary then to calculate the area from which water is collected into the drain, and it is usual to allow for collecting the following quantities of water as the result of rainfall in ordinary districts in England:

From roofs ..	0·75 in. per hour.
From paved yards	0·75 „ „ „
From gravel paths	0·40 „ „ „
From meadow land	0·10 „ „ „

Occasionally, for short periods, a fall at the rate of 1 in. and even more per hour may have to be dealt with from roofs.

Position of Inspection Chambers. With a view to economy it is desirable to use as few manholes as is consistent with efficiency, and to converge as many drains as possible at each. In a soil-drain every connection and every change of direction must be made at a manhole [**42, 43, 44**]. In a rainwater drain the same principle should be observed as far as possible, but if the main run is laid in a straight line to true falls and only conveys rainwater, most local authorities allow junctions to be made with it. When rainwater branches must be taken into a soil-drain, and the connection cannot readily be made in a manhole, a separate rainwater pipe should be laid from manhole to manhole alongside or above the soil-drain, to receive such connections.

Position of Intercepting Chamber. The intercepting chamber [**41**] is usually required to be placed on the owner's land, but as near the public sewer as possible, when one exists, or near the cesspool. In some town districts where houses are built up to the edge of the footway they are permitted in the public footway. In most cases at least one other inspection chamber is necessary, placed close to the most distant point to which the drain requires to be carried.

In the town-house plan [**39**] the house drains and the stable drains have in each case only the intercepting chamber and one other. In the country-house plan [**40**], in which the rainwater drains and soil-drains are separated, many chambers are required, due partly to the large number of branches, partly to the changes of direction. The rainwater drains are given a smaller fall than the soil-drains, which is permissible as they have not to convey solid matter. Details of some of the chambers are given, indicating the method of combining the various fittings described under different conditions [**41-44**].

R. ELSEY SMITH

EXAMPLES OF BEAUTIFUL BRITISH FERNS

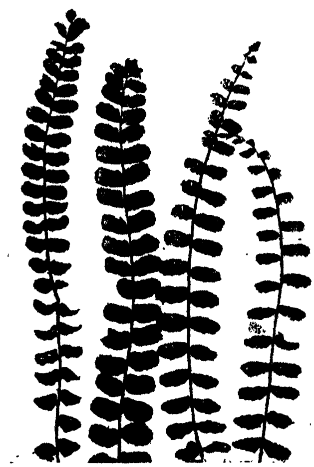

148. HAY-SCENTED BUCKLER FERN


149. KILLARNEY BRISTLE


150. NARROW PRICKLY SHIELD FERN

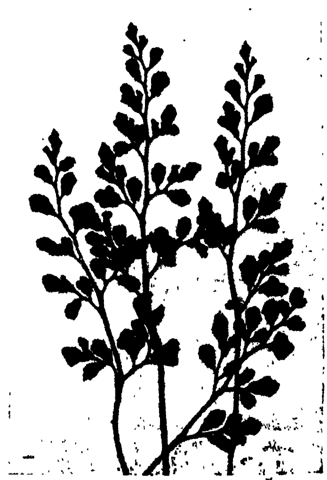

151. SCALY SPLEENWORT


152. ROYAL FERN


153. MAIDENHAIR SPLEENWORT


154. BRITTLE BLADDER FERN


155. PARSLEY FERN


156. WALL-RUE FERN

Structure and Life History of the Ferns, Horsetails, and Club Mosses. Moss Colonies and Liverworts.

FERNS, HORSETAILS, AND MOSSES

The Fern Family. The highest group (*Pteridophytes*) of the seedless plants contains many familiar forms, among which ferns and their allies (*Filicinæ*) take a leading place. It also includes horsetails (*Equisetinæ*), and club-mosses (*Lycopodinæ*).

That part of the geological history of the globe during which we know positively that organisms existed is divided into three great epochs—Primary, Secondary, and Tertiary. The last and shortest of these, which includes the present period, is characterised by the dominance of pod-plants (*Angiosperms*) on land, while naked-seeded plants (*Gymnosperms*) were supreme during the much longer Secondary epoch. Before this, in the immense period of time embraced by the Primary epoch, fern-like plants played by far the most important part in the vegetation of the land [157]. During a part of this epoch the coal-measures of Britain slowly accumulated, and they are chiefly made up of the remains of such plants, some belonging to groups which are now entirely extinct, while others are represented at the present time by species which are mostly small or even of insignificant size.

Tree Ferns. The hot, damp forests of tropical and sub-tropical regions may be regarded as the headquarters of the fern group. In parts of the southern hemisphere—notably Ceylon, Australia, and New Zealand—some ferns grow to the size of trees, and may even make up forests. They somewhat resemble palms in appearance, consisting as they do of a long, bare trunk, bearing a crown of feathery leaves [160].

Parts of a Fern Plant. A fern plant of the kind familiar in this country generally consists of an underground stem (rhizome), which may creep horizontally at some distance below the surface, as in bracken (*Pteris aquilina*), or may be obliquely embedded in it, as in male fern (*Aspidium Filix-mas*). The stems of other species are attached to the bark of trees, or find a home in the crevices of walls or rocks. Brown branching roots grow out from the stem, and serve, as usual, the double purpose of fixation and absorption of a part of the food. The leaves or fronds grow in the contrary direction into the air and light, and do the same work as in seed-plants. They are sometimes broad and unbranched, as in the hart's-tongue (*Scolopendrium*), but their shape is commonly more or less feather-like [148-156]. Young fern fronds are rolled up in the shape of a bishop's crosier, and are thus enabled to force their way up through the soil without getting damaged.

Probably everyone has noticed regularly arranged brown patches on the backs of fern fronds [158]. Each of these is termed a *sorus*, and species differ considerably according to the shape of sori, and their manner of distribution. In bracken they are close to the edges of the frond, and follow its outline; in hart's-tongue they are long streaks diverging from the middle of the leaf, and in polypody (*Polypodium*), so common on tree-trunks, and male fern they are round patches [see also 159]. A sorus may have no special investment, as in polypody, or it may be covered by a membrane (*indusium*), as in male fern. In some cases there are special fertile fronds of different shape from the others, upon which the sori are borne, instances being afforded by the hard fern (*Blechnum boreale*) and royal fern (*Osmunda regalis*), the latter being our largest native species [152].

Spore-cases and Spores. Examination of a sorus under the microscope shows that it is made up of a number of stalked spore-cases, in which are contained a number of angular brown spores [159]. A spore-case is of biconvex shape, with a thickened ring (*annulus*) running round the greater part of its margin. This band is in a state of tension, and when the spores are ripe it tears opens the case and scatters them.

Germination of the Spores. The spores are cells of simple structure, and must not be confounded with seeds, for, as we have already learnt, these are of very complex character. A spore, too, is not, like a seed, the result of a process of fertilisation, but is asexually produced. Should it reach a damp spot it at once germinates. Its firm coats split, and two outgrowths make their appearance—a delicate, colourless, root-hair which grows down, and a green thread that makes its way upward. But few spores are able to effect their work of continuing the species. It has been calculated that, on the average, only one spore per plant succeeds in doing this each season. And if these little bodies were not produced in vast numbers, ferns would soon become altogether extinct. We should naturally expect that the germinating spore would grow at once into a new fern plant; but this is not the case. It gives rise to a small heart-shaped green expansion, the *prothallus* [161], attached to the soil by numerous root-hairs. Prothalli may often be seen in quantity in greenhouses, growing on the mould in which ferns have been planted. The artificial conditions are very favourable to their production.

Upon the under side of the prothallus, in its central region (the cushion), which is thicker than its edges, will be found a group of egg-organs [165], each of which consists of a basal part, embedded in the prothallus, and containing an egg-cell, and a projecting curved region. Scattered about on the same side of the prothallus, but restricted to its thinner part, are a number

of very minute hemispherical projections, the sperm-organs [165], in each of which are produced a quantity of excessively small sperms, shaped like fragments of corkscrew, and beset with delicate threads of protoplasm, in constant movement, enabling the sperms to swim about in the film of moisture covering the prothallus.

Fertilisation. Within the mature egg-organ a sort of slime is produced, which swells up and forces apart the cells making up the projecting portion, so as to leave a passage down to the egg-cell. Meanwhile, the ripe sperm-organs have been burst open in similar fashion, and the liberated sperms swim actively about. The slime which oozes from the egg-organs exerts a chemical attraction upon them, and should a sperm succeed in making its way down to an egg-cell it fuses with it. This act of fertilisation is precisely comparable to the process described under the same name for seed plants. And it is particularly interesting to notice that among the lowest of the latter (*Cycads*), the pollen-grain gives rise to motile sperms, instead of growing out into the usual pollen-tube.

The fertilised egg-cell at once begins to divide, and soon gives rise to a young fern-plant, which remains for a time attached to the prothallus, but ultimately drops off and takes root in the ground. The prothallus now perishes.

Alternation of Generations. We see, therefore, that the life-history of the fern includes two alternating stages: (1) The ordinary fern plant, which produces spores asexually, and (2) the prothallus, possessing egg-organs and sperm-organs. We may call these two stages the *Spore-generation* and the *Egg-generation*, and show their relationship thus:

SPORE-GENERATION (fern plant) — spore — EGG-GENERATION (prothallus) { Egg-organ—egg-cell / Sperm-organ—sperm } Fertilised egg-cell

This remarkable phenomenon is known as "alternation of generations," and is typically seen in fern-like plants, mosses, etc., and many lower forms of plants. It is also characteristic of seed plants in a somewhat modified form.

Adder's-tongue and Moonwort. These small and rather uncommon British ferns differ in several ways from their allies just described, for they possess but a single leaf, which divides into a sterile and fertile part, while each spore-case develops from a group of cells, and not from a single one, as is the case in an ordinary fern. In the adder's-tongue (*Ophioglossum*) [162], the sterile part of the leaf has a simple outline, while the elongated fertile portion is practically a mass of closely crowded spore-cases. But in moonwort [164] both parts of the leaf are branched in a feather-like manner.

Water-ferns (*Hydropteridæ*). The water-ferns make up a small but interesting group of little plants which are either purely aquatic or grow with some exceptions in ground of a swampy character.

The lake quillwort (*Isoëtes lacustris*) [167] is found in this country growing at the bottom of mountain lakes, from North Wales northward and looks at first sight like a stoutly built grass. But it is in reality a relative of

157. A SERIES OF FOSSIL FERNS FROM COAL-MEASURES

158. THE SPORE-CELLS CLUSTERING TO THE UNDER SIDE OF THE FRONDS OF A FERN

159. THE CELLS BURSTING OPEN AND SCATTERING THEIR SPORES

adder's-tongue and moonwort, and if, during the summer, we examine the inner sides of the bases of its leaves, we shall find that each of them bears a comparatively large spore-case. As in all the water-ferns, these are of two kinds, which respectively contain small spores and large spores, and, having regard to the fate of these, we may call the leaves which produce them *male spore-leaves* and *female spore-leaves*. For a small spore germinates to produce a minute male prothallus with a single sperm-organ, while a female spore gives rise to a rather larger female prothallus, which bears a few egg-organs. Of the remaining members of this group, which are more nearly related than quillwort to ordinary ferns, the first to be considered is salvinia [166], a small aquatic plant, native to South Europe. It is entirely devoid of roots, and consists of a stem bearing two kinds of leaves, some being oval and floating on the surface, while the others are finely divided and submerged. The latter play the part of roots, and they are also fertile, for at their bases are found rounded sori containing large-spore and small-spore cases. The spores germinate within these in much the same way as in quillwort.

Marsilea [168] grows in marshy ground, and is represented by European and Australian species. There is a creeping stem, from the under side of which roots are given off. The long-stalked leaves fork into a sterile and a fertile portion, the former terminating in a blade which is divided into four parts, and somewhat suggests wood-sorrel in general appearance. The fertile section ends in a hard, bean-shaped structure, which may be called the *spore-fruit*, and contains a number of spore-cases, of which some enclose large and other small spores. When these are ripe, part of the internal tissue of the fruit is converted into mucilage, which swells up and splits open the firm investments along one side. The spores now germinate to give rise to the two kinds of prothallus, and the fertilised egg-cells grow into new plants.

Pillwort (*Pilularia*) grows in the same kind of places as the last-named plant, and is a European species occurring in Britain. It possesses a creeping stem with roots, and narrow leaves. Parts of their bases are modified into rounded, brown spore-fruits, the shape of which has suggested the popular and scientific names. These contain a number of spore-cases of both kinds, which are liberated by the swelling up of mucilage that bursts open the fruit in a valvular fashion. The rest of the life-history is much the same as in Marsilea.

160. A TREE FERN, CYATHEA INSIGNIS

The Horsetails. The extinct members of the Horsetail groups (*Equisetinæ*) played an important part in the formation of coal vegetation, but all existing forms belong to a single genus (*Equisetum*), most species of which are of comparatively small size [163]. One tropical horsetail (*E. giganteum*), however, reaches the height of over 30 feet, and one of our native forms (*E. maximum*) may be six feet in length.

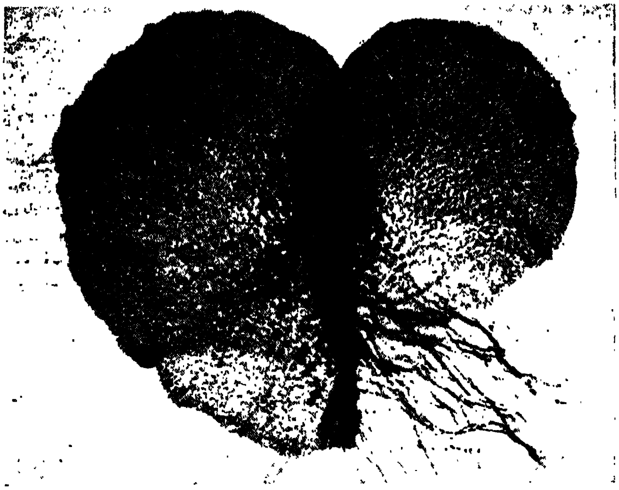
Structure of Field Horsetail. The small field horsetail (*E. arvense*) of Britain abounds in waste places of damp character, and grows from a creeping underground stem, which is very difficult to eradicate. Barren and fertile shoots push up from this in spring to the height of about a foot. The former consists of a hollow, jointed stem, from the nodes of which stiff circlets of narrow green branches grow out, the leaves being represented by a toothed sheath at the base of each circlet. These parts are strengthened by a good deal of flinty matter, so much so that this species and its cousin, the Dutch rush (*E. hyemale*), are used for polishing metal.

A fertile shoot possesses leaves but no branches, and ends in a club-shaped "flower." This is made up of a large number of stalked spore-leaves, each of which bears a set of elongated spore-cases, in which numerous rounded spores are produced, all of the same size, as in ordinary ferns. In some horsetails both fertile and barren shoots bear branches.

How the Spores are Scattered. The covering of the ripe spore splits into four threads, *elaters*, which spread out when dry, but coil round the spore when damp. In the former condition they help to push the spores out of their cases, and give an increased surface which helps dispersal by the wind.

Although the horsetail spores are all of the same size, they give rise to two kinds of prothallus, male and female, which respectively produce sperm and egg organs. The prothalli are not unlike those of an ordinary fern, and the egg-cells are fertilised in the same fashion.

Club-Mosses. The little club-mosses (*Lycopodinæ*) of our moors and mountains are the dwarfed representatives of a group that was dominant in the days when our coal was being formed, at which time many of them were large



161. THE PROTHALLUS PRODUCED FROM A FERN SPORE

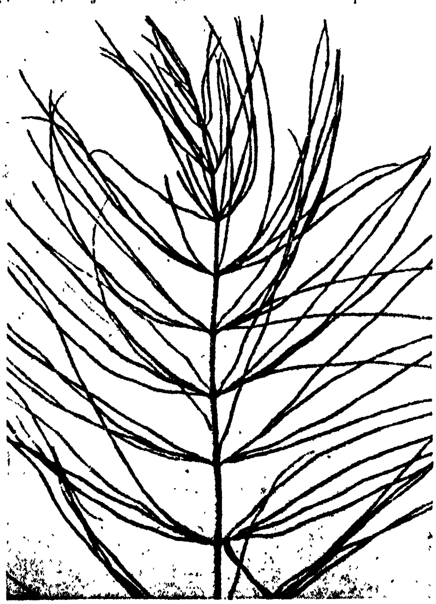
The right-hand photograph is a more highly magnified portion of the prothallus; the conical bodies are the egg-organs and the pale round organs produce the male fertilising sperms.

forest trees. The most striking British species is the stag's-horn club-moss (*Lycopodium clavatum*) [**170**], the long forking stems of which are thickly covered with scale-shaped leaves, and creep along the ground, into which they send roots at intervals. Some of the branches end in elongated cones, comparable to those of horsetails and to the flowers of seed-plants. Upon the basis of the crowded leaves which these bear the spore-cases will be found, each of them containing numerous yellow dust-like spores, all of the same kind. These minute bodies are very resinous, and therefore extremely inflammable. The yellow powder known to the Pharmacopœia as "lycopodium" is made up of them, and by blowing some of this through a gas-jet a bright flash of light can be produced, which has often done duty for lightning on the stage; and it is interesting to know that some layers of coal are almost entirely made up of the spore-cases of extinct members of the group.

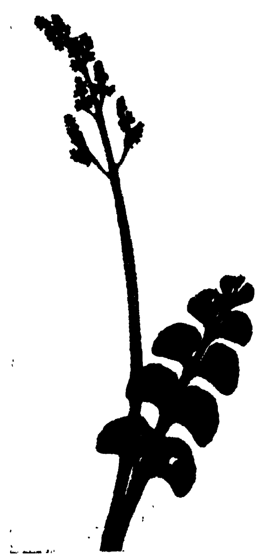
The spores of the stag's-horn club-moss germinate to produce small tuberous prothalli, which live undergound and form a sort of joint-stock company with a kind of fungus, as we have elsewhere seen to be the case with the roots of certain seed-plants. A prothallus bears both sperm and egg organs, and the details of the life-history resemble those of ordinary ferns.

Selaginella. Selaginella is a relative of the club-mosses, and is represented by a large number of species which are particularly common

162. ADDER'S TONGUE

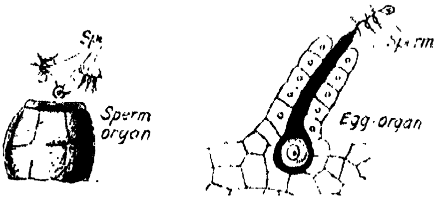


163. COMMON HORSETAIL



164. MOONWORT

in tropical regions. It lives in wet places, and we have one native species (*S. selaginoides*) [169], while others like the *S. Kraussiana* are cultivated in our greenhouses. The plant creeps along the ground after the fashion of a club-moss, but its



165. SPERM AND EGG ORGANS OF A FERN
The egg-organ is shown in ...ction

leaves are thinner and more delicate, in association with the moisture-loving habit. Like a club-moss, too, some of its branches end in cone-like flowers, but the spore-cases are of two kinds, as shown in **169**, producing large and small spores respectively.

In the life-history of selaginella there is a general agreement with the water-ferns. The macrospore germinates into a small female prothallus, which projects from the spore and possesses a small number of egg-organs, while the germinating small spore becomes a very minute male prothallus, which is practically nothing more than a sperm-organ, producing motile sperms, as in many of the cases we have already described.

We may represent the life-history as follows, the same diagram serving for the water ferns:

SPORE-GENERATION — EGG-GENERATION

Selaginella plant { Large spore—female prothallus—egg-organ—egg-cell } Fertilised
{ Small spore—male prothallus—sperm-organ—sperm } egg-cell

The Struggle for a Foothold. There is no doubt that water is the original home of life, and it is only by a long process of evolution that certain groups of animals and plants have become fitted for existence on land. Limiting ourselves for the present to the latter, we may say that marshes, swamps, and damp places in general constitute a sort of half-way house between water and land, and play a very leading part in the tactics of forms which are endeavouring to abandon the old aquatic home. It is also important to remember that the life-history of any particular organism broadly recapitulates in summary form the evolutionary history of the group to which it belongs. Bearing this in mind we shall be able to understand the mysterious phenomenon of alternation of generations, of which several cases have been described.

If we take, for instance, the life-history of a fern, we find a small, relatively insignificant egg-generation (the prothallus) living in very moist surroundings, of which the fertilised egg-cells become the relatively large and complex "fern plants" that constitute the spore-generation, and produce spores which germinate into prothalli. The spore-generation, it is true, flourishes best in damp, shady places, but it is far less dependent upon moisture than the prothallus is, and is adapted in many ways to comparatively dry conditions. Its stem and leaves have firm coverings, by which undue evaporation is prevented, and are traversed by strands which conduct liquid from the roots.

The Beginnings of Flowers. We are probably justified in looking upon the insignificant egg-generation (the prothallus) as being the much diminished representative of the remote aquatic ancestor from which the fern has descended, while the "fern plant," the spore-generation, is a special development that has gradually arisen as an adaptation to the conquest of the land. As we pass up the scale to seed plants, we shall find that the egg-generation becomes more and more reduced, and the spore-generation of increasing importance. And we shall discover the beginnings of flowers, which are simply special shoots bearing spore-leaves, and giving themselves up to the production of spores, either all of one size, as in horsetails and club-mosses, or large and small, as in the case of water-ferns and selaginella.

Alternation of Generations in Seed Plants. All the fern-like plants are more or less thwarted in their attempts to dominate the land, because they still retain in their life-history an egg-generation (prothallus) which is very dependent upon moisture, and partly because the motile sperms, essential for the fertilisation of the egg-cells, have to swim to their destination. But seed plants, though they still retain an egg-generation, have reduced it to very small dimensions, and have so arranged matters that they are no longer obliged, for its sake, to live with "one leg in the water." Let us, then, briefly consider the life-history of a flowering plant in the light of what has just been said.

The Life History of a Flowering Plant. The "plant" itself is the spore-generation, and its flowers are arrangements for producing spores, in this case of two kinds, large and small. The carpels are spore-leaves giving rise to large spores (embryo-sacs), contained in spore-cases (ovules). The stamens are also spore-leaves which produce small spores (pollen

166. SALVINIA

167. QUILLWORT

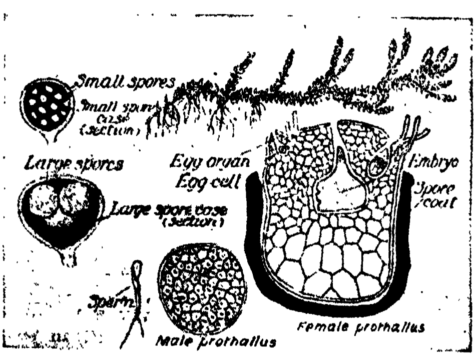
168. MARSILEA

grains), developed in spore-cases (pollen-sacs), of which four are embedded in each anther, at least, in the case of pod plants. The egg-generation consists of male and female

prothalli. The male prothallus is very minute indeed, and represented by the contents of the germinating pollen grain. The stigma provides the necessary moisture for germination, or, in naked-seeded plants, this is provided by the scales of the female cones. We may regard the pollen tube as a sperm-organ, and in most cases the motile sperms have been superseded, some of the contents of the pollen-tube passing directly into the egg-cell. But cycads still produce sperms, which swim about in a small quantity of fluid provided for them by the ovule. It is not surprising that these should be present in the cycads, for they are the lowest of seed plants, and therefore most like the ferns.

The female prothallus is represented by the contents of the embryo-sac, and is safely sheltered within the ovule. In a naked-seeded plant, such as the Scottish pine, this prothallus consists of a small mass of cells (endosperm) formed before fertilisation, and of a couple of egg-organs, something like those of a fern, but much reduced, and each producing an egg-cell. In a pod plant the female prothallus is still more reduced, and so are the egg-organs, but there is a large egg-cell. All this may be expressed in the scheme on this page, which should be compared with that given on the previous page for selaginella.

The conspicuous parts of a flower have been developed, as we have seen, for the attraction of insects or other animals which carry about the small spores (pollen grains). We have considered the use and nature of seeds, and it will be sufficient to add here that recent research has revealed the existence of extinct plants which possessed what may be called incipient seeds, and which form a link between fernlike species and cycads, the lowest form of seed plants.



169: SELAGINELLA AND ITS PARTS

Mosses and Liverworts. Descending a step lower in the scale, we now come to forms of plant life (*Bryophytes*) which are more dependent upon moisture than ferns and their allies. They also have begun the conquest of the land, but have not accomplished so much in that direction. Properly developed roots and strands

170. STAG'S-HORN CLUB-MOSS

SPORE-GENERATION		EGG-GENERATION			
Seed plant	Large spore (embryo-sac)	female prothallus (contents of e. sac)	egg-organ (reduced)	egg-cell	Fertilised egg-cell
	Small spore (pollen-grain)	male prothallus (contents of p. grain)	sperm-organ (pollen-tube)	sperm (or part of contents of p. tube)	

of tissue (vascular bundles), which convey crude and elaborated sap, and give support, are eminently characteristic of the higher land-plants, or, to speak more correctly, of the spore-generation of such plants. Mosses and liverworts possess no proper roots, but only root-hairs, and their small spore-generation is only beginning to develop vascular bundles.

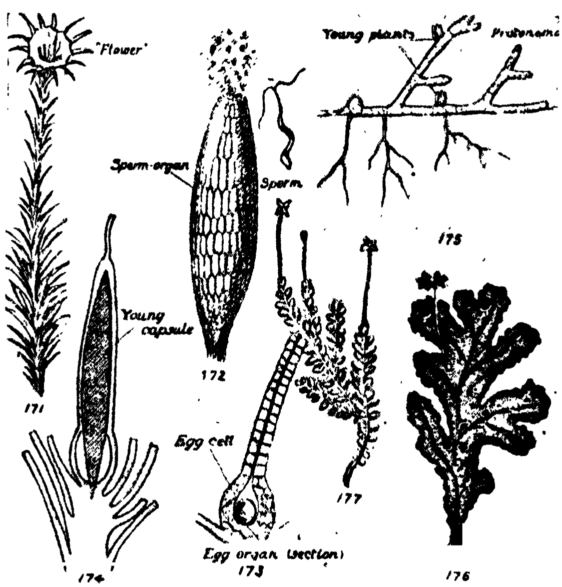
If we examine a fruiting moss we shall see that it consists of a slender stem bearing numerous delicate flattened leaves and brown threads (the root-hairs). Attached to such a plant will be found one or more stalked spore-capsules. There is a well-marked alternation of generations, for the moss plant itself is the egg-generation, and each spore-capsule a spore-generation.

Egg-generation of Moss. Although mosses are closely wedded to damp surroundings, they can stand a large amount of desiccation without being killed. But it is in the wetter parts of the year that they are in their prime, and we shall then find that groups of egg-organs and sperm-organs are developed at their tips, sometimes associated and sometimes not. In hair-mosses (*Polytrichum*) the ends of certain plants present aggregates of red or

orange coloured leaves [171]. If we dissect one of these so-called "flowers of moss," a group of sperm-organs will be found, each of them being a club-shaped structure [172], within which numerous motile sperms are produced. At the time of maturity the sperm-organ is forced open by the swelling up of mucilage, and the sperms make their escape. They swim about in the moisture clinging to the moss—to them an ocean —in search of egg-cells to fertilise.

Flask-shaped egg-organs [173] are produced at the tips of other moss-plants, or on the same plant, and in each of these is an egg-cell. By the expansion of slime a passage is opened down the neck of the flask, and, as in the fern, this slime exerts a chemical attraction upon sperms. If one of these microscopic bodies succeeds in finding its way down to the egg-cell it fuses with and thus fertilises it. The fertilised egg-cell now actively develops to form the spore-generation or spore-capsule.

Spore-generation of Moss. The young spore-capsule develops within the egg-organ, which at first keeps pace with its growth [174]. Ultimately, however, it is ruptured, and its upper part is carried up as a sort of extinguisher - shaped cap (*calyptra*) upon the capsule, which may be seen as a large fibrous structure in hair-moss. The spore-generation never attains an independent existence, but remains embedded as a sort of parasite in the egg-generation. The capsule which it bears is of very different size, shape, and structure in different species. Within this capsule numerous dust-like spores are produced.



171. HAIR-MOSS 172-175. DETAILS OF MOSS
176. MARCHANTIA 177. PLAGIOCHILA

Dispersal of Moss-spores. The top of the ripe moss-capsule falls off, and the opening exposed is bounded by an elegant arrangement of tooth-like strips, the tips of which are sometimes attached to a central membrane. But, in any case, the arrangement is very sensitive to moisture. Wet weather is unfavourable for the wide distribution of the spores by the wind, and the teeth are then closely apposed. But on a dry, warm day they curl up, leaving spaces between them, through which the spores escape. If a moss-spore reaches a suitable damp spot it will germinate, giving rise to branching green threads (*protonema*), upon which new moss-plants are produced as buds [175].

We thus summarise the life history of a moss, placing the more important generation first:

EGG-GENERATION		SPORE-GENERATION
Moss plant	{ Sperm-organ—sperm / Egg-organ—egg-cell }	Fertilised egg-cell— Spore capsule—spore

Mosses are usually found matted together in extensive colonies, which are largely formed by a process of vegetative reproduction. The branches keep on growing, and their older parts decay, while the ends remain to form independent plants. Peat is chiefly formed by the growth of peat-mosses on a large scale. These are far more dependent upon moisture than the ordinary sorts, and their branches and leaves are hollowed out into cavities, by which water is readily taken up.

Liverworts. Liverworts are lowly relatives of the mosses, presenting a great variety in form and habit, but possessing a life-history much like the one just described for a typical moss. Some of them are common on wet banks, or within the reach of spray from waterfalls. Many—such as the marchantia [176] — are flat, green expansions, without distinction between, stem and leaf, attached by numerous root-hairs to the underlying soil.

In this particular case the egg-organs are borne on the under side of upright, umbrella-shaped branches, while the sperm-organs are to be found in a similar position on mushroom-shaped ones. There is also a special provision for vegetative reproduction in the form of little green cups, within which are produced minute rounded *gemmules,* capable of growing into distinct plants.

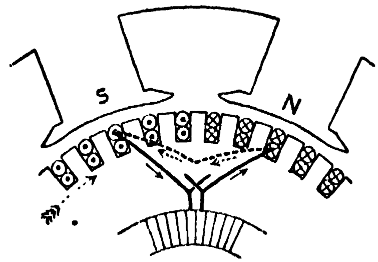
The spore-capsule of a liverwort is not so complex as that of a moss. Its stalk does not elongate till the spores are ripe. These are contained in a rounded swelling, which may split open regularly or irregularly. Scattered among the spores there are usually a number of elastic threads (*elaters*), which assist in the dispersal of these microscopic bodies.

The higher liverworts somewhat resemble mosses in appearance [177], and are often found living among them. Some such forms grow on the bark of trees, and do not lose their vitality if they dry up. J. R. AINSWORTH-DAVIS

The Dynamo—continued. Windings. How to Join up the Armature-conductors. Self-exciting and Independently Excited Dynamos.

THE DYNAMO

Lap Windings and Wave Windings. We have seen that the proper breadth of each loop of the winding is that it should be approximately equal to the pole-pitch—that is, the arc from the middle of one pole-face to the middle of the next pole-face. We have also seen that the loops should be joined up in a regular series. But there are two modes of doing this, and they lead to slightly different results. These two modes of grouping the coils are termed respectively *lap winding* and *wave winding*. To understand these modes, let us adopt a method of representing a current flowing in a wire. It is easy enough to indicate which way a current flows in a wire by simply drawing an arrow by the side of the wire to point the direction, as was indeed done in the article on batteries [p. 371]. But we need also a way of showing the direction of the current in diagrams that show the section of an armature, where the cross-section of the wire appears merely as a small circle. To indicate a current coming towards us in such a section, we will put a dot in the middle of the small circle; and to indicate that a current is going from us, we will put a cross in the circle. Now let 71 represent a section of a piece of an armature of a multipolar dynamo that has the windings laid two-deep in slots. Let us suppose this armature to be revolving right-handedly past the poles, as shown by the dotted arrow. Then, by applying the right-hand rule [p. 1007], it is easy to ascertain that the induced currents will be flowing towards us in those wires which are moving past the south pole, and will be flowing from us in those wires which are passing under the north pole. (If the motion were to be reversed, the directions of the currents would, of course, be also reversed.) Accordingly, mark these directions with dots and crosses, as in 71. Now consider a loop made of two of these conductors by joining their distant ends by an end-bend (shown dotted), their front ends being brought out towards one another. We select as one conductor a wire in the top of a slot under the middle of the south pole, and, as the other, a wire in the bottom of a slot under the middle of the adjacent north pole. This constitutes a typical loop, and we see which way the current will flow around it.



71. HOW LOOPS ARE CONNECTED UP

Successive Laps. Now, the question is, how shall we join up this loop to other similar loops in the other slots? Suppose this machine had been an 8-pole machine, with 40 slots. (A real machine would have a larger number of more slots, but we take this small number as being manageable.) That makes five slots per pole. Then, if the slot under the middle of the south pole be regarded as slot No. 1, the slot under the middle of the north pole will be slot No. 6. There being two conductors in each slot, we may number them as follows. Conductors in the tops of the slots will be called 1, 3, 5, 7, etc., while the conductors of the lower layer in the bottoms of the slots will be even numbers, 2, 4, 6, 8, etc. Our typical loop is made by joining wire No. 1 to wire No. 12. We may make similar loops by joining No. 3 to No. 14, and No. 5 to No. 16, and so on. Now, to join the loops together into a continuous winding, the simplest way is to join the end of the first loop to the beginning of the second, the end of the second to the beginning of the third, so that the order in which the conductors are joined up is

1-12-3-14-5-16-7-18-9-20-11, etc.

It will be seen that in this mode of joining *the winding laps back upon itself*, the loop 3–14 overlapping 1–12, and so on. If the series be continued, we go right round the whole lot, and end off as follows: 69–80–71–2–73–4–75–6–77–8–79–10–1.

Successive Waves. The other mode of grouping is called *wave winding*. To carry it out we shall need an odd number of slots —say, 39 instead of 40. The first slot will contain conductors Nos. 1 and 2, the last slot Nos. 77 and 78. Now consider the loop made by Nos. 1 and 12. Instead of lapping back to the loop made up of Nos. 3 and 14, connect the winding forward to a loop surrounding the next north pole further on—namely, the loop made up of Nos. 21 and 32—and let this be again joined forward to the loop opposite the next south pole in regular succession. Four such loops will then run as follows: 1–12–21–32–41–52–61–72; and this has brought us round not to the slot from which we started, but to the one next to it. It will be seen that the successive steps forward are values of 11 for the front pitch, and of 9 for the back pitch. If we continue on, we should have, after 61–72, the numbers 81 and 92. But there are only 78 conductors in all, so that the 81st is really No. 3, and the 92nd is No. 14; so we get for the next round of the series: 3–14–23–34–43–54–63–74; and so on until we have gone

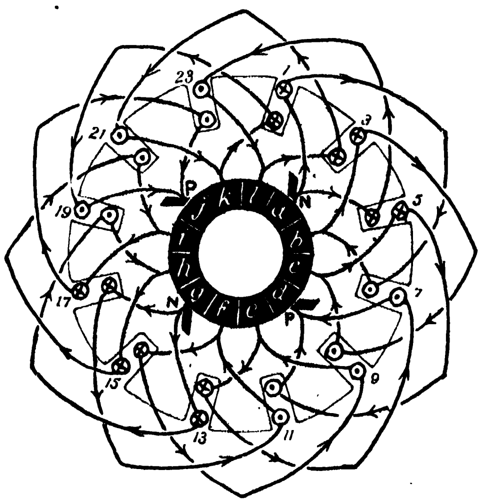
through the whole set and wind up on the eighth round as follows:

19-30-39-50-59-70-1-12;

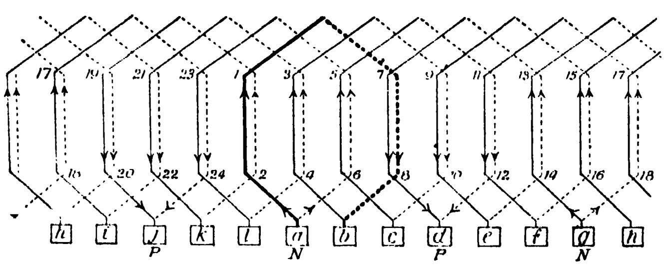
thus ending by becoming re-entrant.

Anyone who wants to become familiar with wave-windings should draw a diagram of these 39 slots around a circle, and join up the conductors in the fashion followed in **74**. We shall merely remark that while for a lap winding any number of slots, odd or even, can be used, for a wave winding the number of slots must be odd, and must fulfil the formula $S = py - 1$; where S is the number of slots, p the number of poles, and y the average number of slots of the winding pitch (in the above case $y = 5$).

Paths Through a Winding. It was remarked above that in any re-entrant winding there are necessarily at least two paths for the current. We have next to examine this point more closely. To help us in this let us consider a 4-pole machine such as **50**. The currents in the conductors that are passing under the poles will have directions as already determined by the rule of the right hand. Now consider the winding scheme for a 4-pole machine, as simplified in the diagram [72]. Here there are supposed to be only 12 slots, with two conductors in each. The four magnet-poles are not drawn, they must be imagined; and we can describe their positions by the respective quadrants they face. But we see that if the four poles stand as in **55**, and if the armature is revolving right-handedly, as in **71**, the induced currents will be flowing towards us in all wires that are passing through the NW and SE quadrants (being marked with *dots*), and will be flowing from us in all wires that are passing through the NE and SW quadrants (being marked with *crosses* in the diagram). Now let these 24 conductors be joined up in a lap winding, taking the back pitch as 7 and the front pitch as 5—that is, No. 1 conductor is joined at the back of the loop to No. 8 conductor—and then let the connection at the front from No. 8 lap back to No. 3. The numbering and connections of the various conductors is perhaps better understood by use of a *developed* winding diagram such as **73**, which represents the same winding as though laid out flat. In the *radial* winding [72] all the end-bends of the loops that are at the "front," or commutator, end of the armature, are drawn at the interior, while all the end-bends at the "back" of the armature are drawn at the exterior of the diagram. Now, to both these diagrams [72 and 73] let us add arrows to show the directions of flow of the currents. For example, in conductor No. 1, which is in the NE quadrant, the cross in the small circle indicates that the induced current is flowing *from* us. Let us then add arrow-heads on the front end-bends leading to No. 1 in that at the back leading from No. 1 to No. 8. When we shall have similarly marked all the connecting wires, we shall discover that there are four points on the winding to or from which the currents converge. Thus, two currents run to converge *toward* each of the two points marked P (positive), and two others run *from* each of the two points marked N (negative). As shown in both 72 and 73, the windings are joined at regular intervals by risers to the bars, or segments, of the commutator, marked a, b, c, d, etc. A little consideration will show that it is just at these four points marked N, P, N, P, that the brushes must be set to collect the currents. The two positive brushes at PP must be joined together and connected to the positive main of the circuit; and the two negative brushes at NN must similarly be joined to the negative main of the circuit, and it now becomes evident that in this lap-wound 4-pole armature there will be four paths—all "in parallel" with one another—from the negative to the positive side. If the machine were delivering, say, 100 amperes, 25 amperes would flow along each of the four paths. This is one of the properties of a lap winding—*there will be as many paths through the armature windings as the machine has poles;* and there will be needed *as many sets of brushes* around the commutator as the machine has poles.



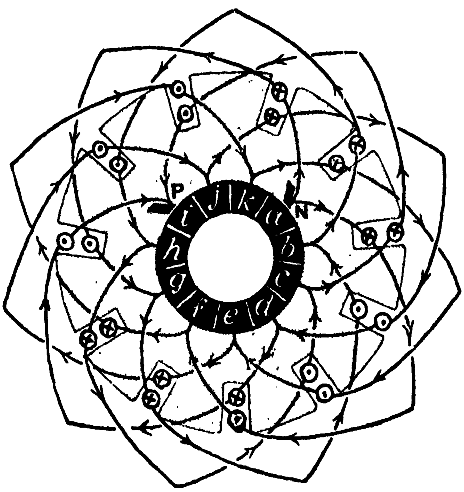
72. LAP WINDING, RADIAL DIAGRAM



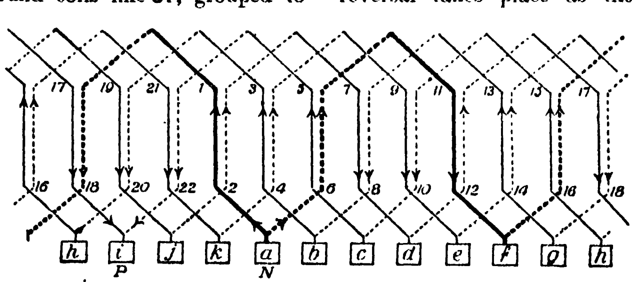
73. LAP WINDING, DEVELOPED DIAGRAM

Series Parallel Circuits. Now turn to the case of the wave winding. The corre-

sponding diagrams are given in **74** and **75**, the former being a radial diagram, and the latter a developed diagram. The number of slots is 11, of conductors 22, and of commutator bars 11. It is still a 4-pole machine, with induced currents coming toward us in the NW and SE quadrants, and going from us in the NE and SW quadrants. The winding pitches back and front are both 5, for No. 1 is joined at front to No. 6, and No. 6 at back to No. 11. If now we think out the directions of the currents, and draw the arrow-heads in all the end-bends, we shall discover that there are *only two* points in the winding where the currents converge—one P (positive) and one N (negative). In this case, therefore, the adoption of a *wave winding* leads to the result that though the machine has four poles, *there are only two paths in parallel through the armature*, and two brush-sets only will be needed, and these must be set at a distance of one pole-pitch apart on the periphery of the commutator. It is a property of a wave winding (if made like this, with one slot fewer than an exact multiple of the number of poles) that *two brush-sets only are needed, whatever the number of poles;* and there will be two paths only through the windings from negative to positive. Such armatures are sometimes called *series wound*, though *series parallel* is more accurate. This kind of winding (using former wound coils like **57**, grouped to form a wave winding) is preferred for tramway motors and for variable speed motors generally. It is also good for such generators as are to give relatively small currents at high voltages. By a modification of the same plan windings can be found which will give either two, four, or six paths through the armature of a multipolar machine.



74. WAVE WINDING, RADIAL DIAGRAM



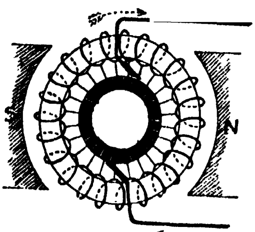
75. WAVE WINDING, DEVELOPED DIAGRAM

Rocking the Brushes. It will now be evident why the brush-sets must be mounted on an adjustable frame. It is that they may be set at the exact spot, or *neutral position*, where the currents tend to converge. If they are shifted from that spot, the usual effect is an outburst of bright sparks, which are destructive of the commutator. The so-called *rocker* is a clamping frame to procure exact adjustment of position.

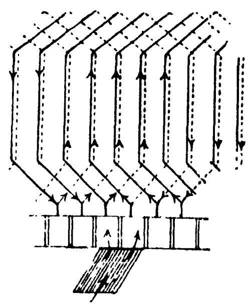
Ring-wound Armatures. Earlier in date than either the lap-wound or the wave-wound toothed drum armatures were the ring-wound armatures of Pacinotti (toothed ring, 1864) and of Gramme (smooth ring, 1870). In both these the wires were coiled on a ring-core, the wire being wound on the ring in sections, and each section being joined up to the next, so as to make a re-entrant winding. This winding was connected down at regular intervals to the segments, or bars, of a commutator. The scheme is shown diagrammatically in **76**. In fact, though the separate coils do not overlap one another, the winding progresses regularly around the ring, and precisely resembles in its properties a lap winding, save that each turn of the winding threads back through the interior of the ring. This prevents the use in ring-wound armatures of former-wound coils. The commercial introduction of the Gramme ring gave an immense impetus to the infant industry, but ring windings are never now used, except in quite small machines and little motors. The bipolar lap-wound drum winding was due to Von Hefner, in 1872.

Sparkless Commutation. If attention be directed to individual loops of the winding it is seen that as they pass along under successive poles the currents induced in them are continually reversing in direction. The reversal takes place as the slots containing the sides of the loop have passed away from being under the poles and are just coming again under the tips of the next pair of poles. This is the moment when the corresponding bars of the commutator are passing by the collecting brush. As the brush is generally broad—broader than the breadth of a commutator-bar—it follows that at the time when the brush makes contact with two bars of the commutator at once the coil, or loop, whose ends are joined to those two bars will be short-circuited. If the brush be broad, the duration of this time of short circuit will be longer than if the brush be narrow. Now, it takes time for a current in a loop to be reversed in direction, for the current has to die down and then grow again, flowing in the opposite sense. Broad carbon-brushes give the

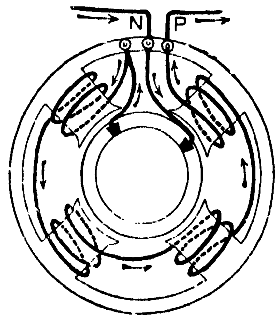
necessary time for this operation, and the resistance of the film at the surface of contact acts like a valve-port of varying size to turn the current off and on again in the loop. Thus the resistance at the face of a broad carbon-brush affords a means of *natural commutation* without sparking. But if the current to be collected is too great, or if there is not time enough allowed in the brief duration of the passing contact, and if metal brushes are used, then resort must be had to *forced commutation*. By this term is meant the introduction into the loop or coil that is undergoing commutation of induced electromotive forces that tend to *force* the current in it to reverse during the time of contact with the brush. Such forced commutation is effected in one of two ways. The oldest way is to rock the brushes to a position *forward* from the



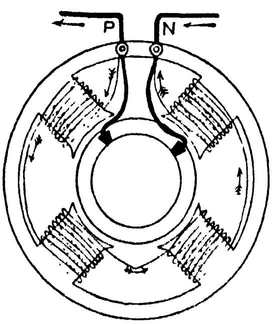
76. RING WINDING



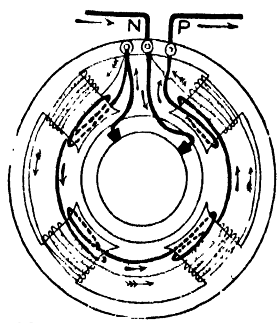
77. THE ACT OF COMMUTATION



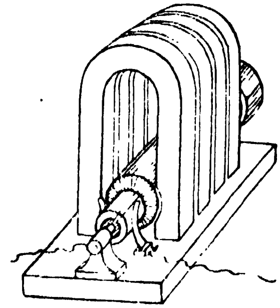
78. SERIES EXCITATION



79. SHUNT EXCITATION



80. COMPOUND EXCITATION



81. MAGNETO

neutral point, so that the coil, or loop, is actually beginning to cut the magnetic lines during the time of brush contact. The newer mode is to provide *auxiliary poles*, called reversing poles, between the ordinary poles of the field-magnet.

Calculation of a Dynamo. The electromotive force of a dynamo depends on the strength of the magnet-poles, the number of conductors on the armature, the speed and the grouping of the windings, and is readily calculated as follows. Let N stand for the number of magnetic lines that any one pole—all the four poles should be equally strong—send across the air gap to the armature—that is to say, the amount of magnetic flux per pole. This will be usually some number between 1,000,000 and 20,000,000. Let p stand for the number of poles. Let c stand for the number of circuits, or paths, through the windings (2, in wave-wound armatures, or as many as p in lap-wound armatures). Let Z stand for the number of conductors all round the armature, this being the same as the number of slots multiplied by the number of conductors per slot. (In actual machines this number is seldom under 80, and seldom over 1200.) Lastly, let the number of revolutions per minute be called RPM, so that the number of revolutions per second will be RPM ÷ 60. Then it is clear that the number of poles passed in a second by any one conductor will be equal to $p \times$ RPM $\times 60$; and the number of lines cut per second by any one conductor will be equal to N $\times$ p $\times$ RPM $\div$ 60. Now, one volt is equal to the cutting of 10^8 (that is, 100,000,000) of lines per second. Hence, the number of volts generated in one conductor of the armature will be N $\times$ p $\times$ RPM $\div$ (60×10^8). But there are (Z) conductors, and these are all joined up together in a particular way so that they constitute (c) circuits or paths, and the number in series in each circuit or path will be Z $\div$ c. Hence, if we multiply the volts generated per conductor by this number we find an expression for the whole voltage (E) generated by the machine. So we write

$$E = \frac{p}{c} \times \frac{\text{RPM}}{60} \quad Z \times N \div 10^8$$

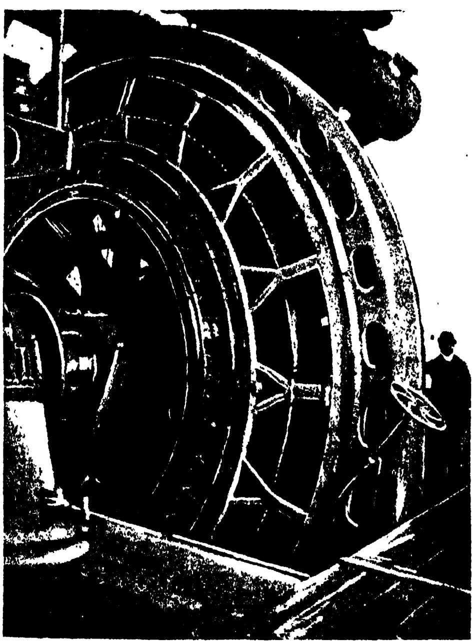
For example: In the dynamo depicted in 50, $p = 4$; N = 2,700,000; $c = 2$; Z = 444; RPM = 640. Making the calculations, we have:

$$E = \frac{4}{2} \times \frac{640}{60} \times 444 \times 2{,}700{,}000 \div 100{,}000{,}000 = 256$$

volts.

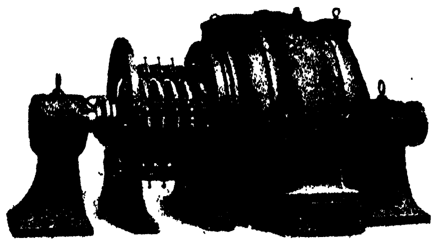
Excitation of Magnetism. There are several ways of exciting the magnetism of the magnets of dynamos. In the early magneto-electric machines of Faraday the magnets were either permanent magnets, of hard steel, or else soft iron electromagnets, separately excited by means of batteries. In 1851 Sinsteden suggested using the current from a small permanent magnet-machine to excite the electromagnets of a larger machine. In the years 1866–7 several inventors—among them Wheatstone, Siemens, and Varley—independently proposed to render machines self-exciting by passing either the whole or a part of the current from the armature around the field-magnets. About twenty years later compound winding was introduced. Figs. **78**, **79**, and **80** show respectively schematic diagrams of the connections of the magnetising coils in a *series-wound* dynamo, in which the exciting coils receive the whole current, and are in series with the outside circuit; a *shunt-wound* dynamo, in which the exciting coils receive a small fraction only of the whole current, being of fine wire, and are in shunt with the external circuit; and a *compound-wound* dynamo, in which shunt coils give the principal magnetisation, while some series coils serve to increase the magnetisation as the load in the external circuit increases.

Series-wound dynamos are very inconstant in their voltage, as this depends on the magnetism, and the magnetism will vary with the load, being very small at small loads, and large at full load.



82. COMMUTATOR END OF 2700 KILOWATT 36-POLE DYNAMO, AT BOSTON, AMERICA.

Shunt-wound machines are very nearly constant in their voltage at all loads, as the magnetism is practically constant, and the voltage-drop at full load, due to reactions and internal resistance, may be less than two per cent. of the initial value. Compound - wound machines are constant in their voltage at all loads, or may even be made —by increasing the number of series coils—to cause the voltage to rise at times of full load. Such over-compounding is useful in tramway generators.



83. CONTINUOUS-CURRENT TURBO-DYNAMO OF 500 K.W., 500 VOLTS, 2500 R.P.M.

Magneto-electric Generators. Little machines with permanent magnets of hard steel are still employed to generate currents on a small scale, as toys, and for ignition purposes in automobiles. In such cases [**81**] the magnets are bipolar horseshoes, the armature is reduced to the simple shuttle-form invented by Siemens in 1855, and the commutator shrinks back to the primitive form of a bit of copper tube split into two halves.

Turbo-Dynamos. The high speed of modern steam turbines introduced several new problems in dynamo design. It is necessary to use armatures of small diameter and of considerable length, with very stout shafts, while the number of poles is limited to two or four. The British Westinghouse Company have overcome the difficulty of securing good commutation by adopting radial commutators, as shown in **83**, where a current of 1250 amperes is collected at 500 volts from a 500 KW generator, running at 2500 RPM. The current is collected from the flat face of the radial commutator segments, and in this plan carbon brushes are thoroughly successful.

Another plan, adopted by the Parsons Company, of overcoming the difficulty of commutation with turbo-driven continuous current dynamos is to use a reducing gear between the turbine and the dynamo. It permits the employment of turbines of higher speed, which are consequently cheaper, and as the ratio of gearing may be 8 to 1, dynamos of quite ordinary speed can be used. In these comparatively slow-speed machines it is much easier to secure good sparkless commutation, as the time allowed for the reversal of the current at each line of brushes is considerably greater than is possible in machines running at 1500 or 2000 revolutions per minute. This combination has proved thoroughly satisfactory, and Messrs. Parsons have constructed machines up to 4000 KW on this principle. Probably there will be further development in this direction in the immediate future.

SILVANUS P. THOMPSON

The Instrument. The Two-fold Function of the Keys. Control of the Key Hammer. Keyboard and Pedals. Correct Position of the Hands.

THE PIANOFORTE

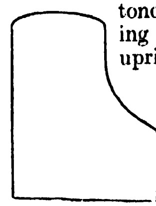
We have already studied the Theory of Music, the nature of Scales, the laws of Tonality and the nature and function of Rhythm, etc. We have learned how music is written down, how to read its notation. We have now to learn to reproduce written music—to "make music," as the Germans say—and to do this by means of the pianoforte.

Our pianoforte education has two distinct branches. In the one we learn to conceive the effect intended by written music. We learn to hear it with the mind's ear, we learn to think it. In the other we learn to express this thought by sounds that we and our audience can hear. This latter branch we call *technique*, in the fullest sense of the term.

Technique. The learning of Technique (the power of expressing ourselves) used to depend on an aptness for imitation. Our teachers played, and we did our best to imitate them ; and, by dint of much trying, sometimes succeeded. They could teach us these matters of execution by example and suggestion only. But now both the how and the why of good piano technique have been discovered and written down for us, so that it is possible for all of us to learn from books. These books are "The Act of Touch," a scientific treatise, and "First Principles of Pianoforte Playing," a student's primer, both by Tobias Matthay. They show how it is possible to acquire (in a direct way) all the different forms of expertness included in the term Pianoforte Technique. For the term thus used in its widest sense simply means the ability to use the keys effectively and easily, and, as Mr. Matthay has said, "on our correctness in the Act of Touch, therefore, depends all success in pianoforte playing in whatever direction, agility, beauty of tone, brilliancy, power, and ability to give those inflections of tone from note to note which render music intelligible." Our entire technique depends, therefore, on our obedience to these Laws of Touch, and on our technique again depends entirely our power of expressing what we feel.

To begin the study of pianoforte playing in this direct and scientific way which has thus been made possible for us, we must, before thinking of our fingers and hands, find out what the piano is, and what treatment it requires from us.

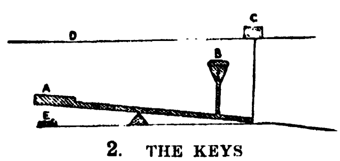
Instrumental Facts. The pianoforte is a harp-like instrument enclosed in a wooden box, the nature of which is disclosed by the "case" of a "grand" piano, which still retains this harp-like shape, although now supported table-wise on three legs. The upright or "cottage" piano, although its case is quite different in shape, is still harp-like within. The strong metal frame [1] strung with wires, from the short, thin ones giving the highest tones to the stout long ones sounding the bass, is thus no longer held upright by the player like a harp, nor are its strings plucked by his fingers. But, instead, carefully poised *hammers*, covered with thick felt, are driven against the strings to set them in vibration. These hammers are controlled by a set of cunningly devised wooden tools, overlaid with ivory or ebony at one end—the end that presents itself to the player's fingers.



1. FRAME

The instrument consists of two distinct portions : (1) the music-making portion—*i.e.*, the strings and their reinforcing sounding-board—and (2) the set of tools wherewith we may induce the sound.

Function of the Keys. Now, these "tools" have a two-fold function. They are see-saws, offering an ivory or ebony *key* to the finger at one end, and furnished with a hammer to strike the strings at the other end ; and these "keys"—note this—control the actions, not only of the hammer with which we excite tone at will, but also of the "damper" with which we stop off tone at will. Thus the keys are the tools with which we chiefly command the vibratory—*i.e.*, sound-producing powers of the instrument, and we must examine them closely. The key is a lever, of the nature of a see-saw, and its position and action are roughly shown in Fig. 2.



2. THE KEYS
A. Ivory Key-end. B. Hammer. C. Damper. D. String. E. Key-bed felt

Control of the Key Hammer. Let us press gently on the ivory end of one of the keys of the piano. It will go down under the pressure (as would a see-saw), and, the other end rising, will, if the action be swift enough, throw the hammer against the strings. The strings vibrate and produce a sound. Now release the key from the weight of the hand and arm ; the key will rise, and, as it rises, the sound will cease. What has happened ? When, by the see-saw motion of this key-end, we managed to throw the hammer at the other end against the string, did the hammer, after hitting the string, continue to press against it ? No. For, if it had done so, the string would not have been

free to vibrate, and no tone would have resulted. What happened was this: the hammer, as soon as the sound was produced, fell back a little way from the string and allowed it to vibrate freely; and this the string continued to do till we suddenly released the key, and the tone as suddenly ceased.

The Damper. Why did this happen, and why must we keep the key depressed if we wish the sound to continue? Because the key, when depressed, is keeping the damper off the strings, and when the key is allowed to rise the damper is permitted to settle down again on the strings and stop their vibration. Remember, then, that when a key is moved it is the *beginning* of the sound which indicates that its hammer function has been fulfilled—all that remains, the continuance of the sound, depends on its damper function. And this is the first thing we must learn, and the last thing we may forget in using piano-keys to make music.

The Key-bed. We know something about the key with its hammer and its damper attendants, but in the key's retinue there is another small unseen, and at times ill-treated, appanage that concerns us as pianists, and must not be overlooked. This is the little piece of felt under the extreme finger-end of the key, which prevents the key from jarring against its wooden "bed" when it is pushed down. The see-saw key manages to throw the hammer against the string just before it (the key) reaches the bottom of its "bed," and if we were keen enough always to listen for the beginning of the sound and never to move the key any further than to that moment of sound-birth, these poor down-trodden key-bed cushions would be unnecessary. But careless, unskilful players, and even adepts at times, try to drive the keys too far down, and these "felts" in the bottom of the key-bed act like buffers and soften a probable, but quite uncalled-for, collision which might otherwise prove disastrous to the pianoforte mechanism. They may thus be used, but should never be abused, and, to quote Mr. Matthay, "should certainly not be squeezed 'as though they were ripe fruit from which we could extract sound-juice.'"

The Keyboard. The finger ends of the keys are not all alike. They are grouped in easily recognisable patterns in black and white. The even row of ivory—in full "grands" 52—is backed and intersected by a higher and narrower row of ebony keys (36), and these fall into alternate groups of twos and threes. The upright "cottage" piano has a slightly smaller compass, when only eighty-five keys, and sometimes less, will be found. The entire series is called the keyboard, and the player is expected to reach and control with one or the other hand each key in this "manual" [6]

Damper Pedal. But in addition to the keyboard, or manual, we shall find two pedals to be worked by the feet. The right-foot pedal controls the dampers. Depressing it, we raise all the dampers simultaneously off the strings. With the damper pedal thus depressed, a tone produced by the down movement of a key will continue to sound even after the key has been allowed to rise. But this damper pedal not only prolongs the sound, even should the key rise—it affects also the *character* of the sound. For, all the strings of the instrument being by its action left free to vibrate, many of them vibrate in *sympathy* with the hammer-affected strings, adding thus to their original volume of sound, while by the non-percussive quality of their tone they affect also—and this is important—*its quality*. This right-foot pedal is often termed the "loud" pedal. It may be used while playing at one's softest, but its application will be treated further on.

The "Una Corda" Pedal. The other pedal is controlled by the left foot, and its function also is one of affecting the tone quality of the instrument. To explain its use we must again examine the harp-like arrangement of the strings. The long, thick bass strings are single—one to each hammer and key—but, as with the rising pitch the strings get shorter and thinner and consequently weaker in tone, we have two strings tuned to one pitch, and, higher up, three. The left-foot pedal, when pushed down in a "grand," moves the whole keyboard with all its hammer mechanism a little to one side, so that a hammer no longer strikes all the strings allotted to it, but leaves one unstruck, and this one, sounding with a *sympathetic* vibration only, modifies the character of the tone.

That the part of the hammer which comes now in contact with the strings is less used, and consequently softer, will also slightly affect the tone. The left-foot pedal is often erroneously called the "soft" pedal. It certainly does weaken the tone-amount, but we may play at our softest without it. It is properly termed the "una corda"—*i.e.*, one-string pedal. The early piano did not have more than *two* strings, and the "verschiebung"—to use the German term for the "una corda," meaning the pushing aside—permitted the hammers to strike only *one string*. The damper and "una corda" pedals may be used together. Care should be taken when using the "una corda" pedal to *fully* depress it, provided it is properly adjusted.

How the Keys are Named. Most "uprights" are without this device, and are provided instead with a strip of felt to soften the tone, or other devices, none of which, however, takes the place of the proper "una corda."

Roughly speaking, the earlier music, even up to the eighteenth century—*i.e.*, before Beethoven's time, may be and often *must* be played *without* the use of either pedal, while most of the pianoforte music of the nineteenth century—that of Chopin and Schumann, for instance—cannot be adequately performed without the use of one or both.

Now let us return to the keyboard, for it is with the keyboard that we shall have to occupy ourselves chiefly; *but* let us never forget—as pianists are only too apt to forget—that the

keyboard is *not* the instrument, but merely the "set of tools" with which we may use it. We must learn, then, to be expert with these tools, so let us make their better acquaintance. Seated at the middle of the keyboard, let us pass our hands over it. It presents an uneven surface to the touch, the ebony keys lying higher than the ivories. This uneven surface is an advantage.

We must learn to read easily the music written to include the black keys, since it is easier to *play*, though more difficult at first to *read*, than music employing only or mostly the white keys.

What, tonally, does this keyboard command? A series of sounds, each half a tone apart. And its 88 keys are named with but seven letters of the alphabet—from A to G. The white keys only are named; the ebonies take their names from the ivories that lie next to them. This series of seven letters repeats itself throughout the extent of the keyboard; that from A to G was the old form of our modern minor scale, that from C to B the prototype of the modern major scale.

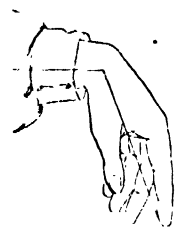
Eye Knowledge of the Keyboard. We must learn to recognise quickly and surely the place and letter name of each white key by its place in the *keyboard pattern*, by its relation to the groups of two and three black keys. Take D first, between *two* blacks, and find D's all over the keyboard; listen to them—all alike though different. Next find C's and E's, next-door neighbours to D's; add B's and F's, each at the extremes of the three black-key groups; and finally add A and G. We must work at this (with other studies) for days or weeks till mastered. Later, add knowledge of altered notes, notes raised or lowered half or whole tone. For such sharpened (raised) or flattened (lowered) sounds we must use the contiguous black or white keys [3]. But finding the keys by the eye, and testing their pitch, and trying to remember this by ear (as the musician must do), is, after all, only the beginning of knowledge for the pianist. *He* must learn to find and recognise the keys *blind*. This he can do only by the sense of touch and by mental muscular measurements. Again, to do this, he must learn with his fingers and hands to *rest on the keys*.

3. RAISED AND LOWERED NOTES

If we have studied carefully every word of what has been said we now know something of the instrument, and of the mechanical means provided in it for producing tone.

Importance of Resting. The next question is, how must we *use* the keys? How direct the arm, hand, and finger against the keys to move them? We must learn, first, to *rest* on them, that our sense of touch may tell us where they are, and that another sense—"the muscular sense"—to which we must pay great heed, may tell us how heavy they are, *how much resistance* they offer to our resting weight. In order that the fingers may really *rest* on the keys, the hand must be allowed to hang loosely—limply—from the arm. We must learn this first.

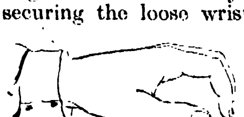
In the daily active use of the fingers (apart altogether from piano playing or study) the hand never hangs from the arms; yet in active finger piano playing it must learn to do so. This is a muscular condition which, in active use of the fingers, is quite new to us. We must study it, understand it, and be able to induce it with perfect ease, and never rest satisfied without daily testing it at the keyboard and away from it.



4. LOOSELY HANGING HAND

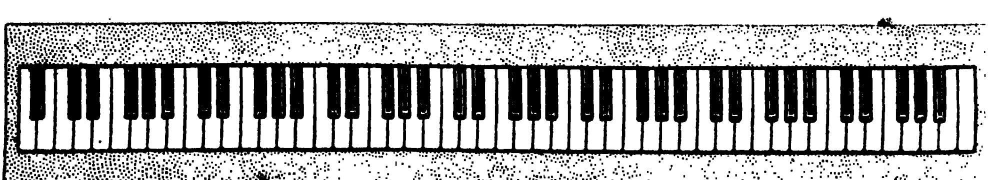
Position of the Hand. To learn what we mean by hanging the hand loosely on keys, let us try holding the hand *over* the keys, but not touching them, in the way indicated in 5.

It is evident that *as long as we do not touch the keys* the hand (at this angle to the arm) is supporting itself; it is *not* hanging loosely from the arm; we are using its upholding muscles, the muscles that prevent the hand falling by its own weight. These must relax; they must relax so that the hand in playing may be supported on the keys by the fingers. The appearance, the mere *position* of the hand when the fingers are on the keys, will not help us in securing the loose wrist; for the wrist may be held high, medium, or low, and in any of these various positions may, or may not, be stiff. If we would make sure of the loose wrist we must see to it that the hand is really *suspended* between arm and fingers, and that being the case it will hang loosely whether the wrist-end of the fore-arm be held high or low.



5. HAND UPHELD BY ITS OWN MUSCLES

M. KENNEDY-FRASER



6. THE KEYBOARD OF A FULL GRAND PIANO, SHOWING ITS 88 KEYS

The Preparation of Fibres for Examination. The Structure and Characteristics of Cotton and Wool

FIBRES UNDER THE MICROSCOPE

THE various textile fibres used in commerce all possess distinctive features, which make them suitable for the different purposes to which they are applied. When they are examined under a good microscope, it is easily possible to see the difference that exists. In this way, wool may be told from cotton, cotton from linen, and linen from silk, and it is not impossible to tell cotton that is in its natural condition from cotton which has been mercerised, and to say whether wool which is sold as unshrinkable has been treated with chlorine.

It is true that the textile trades have not yet placed the examination of their raw materials on a scientific basis, as is the case in many other manufacturing industries, but there are many mills and warehouses in which the microscope is in daily use, and there is no doubt that a more general knowedge of its possibilities would bring it into common use in all the textile trades.

Identification of Fibres. It is not only possible to discover the nature of any given raw material which forms the warp or the weft in the fabric under examination, but the size of the different fibres can be easily measured, and the dimensions of the spaces between the various threads can be ascertained with accuracy.

For practical purposes it is quite unnecessary to have the microscope at high power. A fault in any cloth can be readily detected if it is magnified thirty times, and it is only in the case of the finest silks that greater enlargement than eighty times is necessary. With an eyepiece that will give about thirty magnifications with a two-inch objective, objectives of 2 in., $\frac{3}{4}$ in., and $\frac{1}{4}$ in. will answer any purpose that is likely to arise in the examination of fabrics or textile fibres. Low power lenses have the great advantage that they can be bought at a much more reasonable figure than similar lenses of higher power. They are also much deeper in focus. That is to say, if two fibres, each one-thousandth of an inch in diameter, are lying across one another, they may both be photographed with the two lower of these lenses, so as to give a good sharp definition. On the other hand, the focus of $\frac{1}{12}$ in. or $\frac{1}{16}$ in. oil immersion objective is so shallow that if the top of a fine fibre is in focus, the bottom will be badly blurred.

The Effect of Refraction. In working with such a set of lenses there is, therefore, only one thing to be feared, and as soon as the operator understands how to overcome the difficulty caused by refraction he will be able to make investigations with quite sufficient accuracy for any practical purpose.

The effect of refraction is most easily understood by those who know the appearance of tiny bubbles under a microscope. A student unacquainted with the laws of refraction would naturally expect it to be easier to see through a bubble than through water, because air is the more transparent medium of the two. But, as a matter of fact, the tiniest bubble shows under the microscope more like a leaden shot than anything else. A large one appears like a solid ring. A bubble appears dark because the rays of light are all deflected by the circular skin of water, so that those which would otherwise come to the lens are turned aside. Exactly the same thing is true when fibres are being examined. The light is deflected from their curved surfaces in such a way that the sides of a fibre nearly always appear to be dark. It is very easy to prove that this is entirely due to refraction.

Preparation of Fibre for Inspection. In order to get fibres in focus for microscopic examination it is always convenient to press them between plates of glass. For many purposes this is quite sufficient, but the passage of the light from the air to the fibre and again into the air invariably deflects the ray, and if the refraction is to be avoided, all the space between the two glasses must be filled with some transparent substance of which the refractive index is the same as that of the material under examination. For a cursory inspection, the writer uses water, but glycerine and benzine are better, and a solution of Canada balsam in benzine is best of all. It is nearly always used for the mounting of any fibre in the form of a permanent microscopic slide, and whereas water only partially corrects refraction, the balsam does it perfectly.

If, then, a fibre is first examined between two glasses with nothing but air between them, its sides will appear dark, but the moment it is immersed in benzine or balsam it becomes perfectly transparent to the extremity of the scales, so that the saw-like serrations which exist on wool may easily be detected. It is because some workers are unacquainted with these facts that they make serious mistakes as a direct result of imperfect observation.

Characteristics of Cotton Fibre. Of all the textile trades in this country, the manufacture of cotton stands easily first. It is, therefore, only right that the characteristics of the various cotton fibres should be thoroughly understood, and that the industrial value of these characteristics should be rightly appreciated.

There is one feature in which all classes of cotton differ from every other kind of fibre. Whatever may be their quality, or, in other words, their size, when seen under the microscope, all fibres strongly resemble a piece of twisted tape. Sometimes fibres are twisted from one

end to the other with a hundred turns or more in their length. Sometimes places may be found that are very nearly straight, and in others right-handed twist and left-handed twist may exist in the self-same fibre.

Unfortunately, the various fibres in cotton from any country differ a good deal from one another. They differ both in the number of turns of twist and in their actual size, and though Sea Island cotton is estimated to be quite 25 per cent. finer than Upland American, it will certainly contain many fibres which are coarser than the finest in the Upland quality. This means that a very large number of fibres must be examined and measured if an accurate average is to be obtained, and it is therefore simpler to consult recognised authorities on the subject.

Dimensions of Fibre. There is a consensus of opinion which makes it possible to estimate the dimensions very accurately. They are approximately as given in the following table:

DIMENSIONS OF COTTON FIBRE

COTTON	Length in inches.	Diameter in inches.	Relative number of turns per inch.	Counts they will spin to in yarn.
Sea Island	1·8 to 2·5	1-1500th	240	300, 400
Egyptian	1·2 to 1·75	1-1400th	220	800, 200
American	1·0 to 1·2	1-1200th	140	30, 60
China ..	·75	1-1100th		20
Indian	1·0 to 1·9	1-1300th		30, 40

These figures show a definite reduction in length from Sea Island to Egyptian [1], and Egyptian to American [2], but the student must not expect that he will necessarily find similar relationship between any groups of fibres that he may chance to select from the cotton of various countries.

The value of cotton depends on the relation of its length to its diameter, and the number of turns that it contains. It is a combination of the three that is necessary, and as the length of the fibre cannot be measured under the microscope, it is clearly impossible for the value to be judged by the microscope alone. In fact, it is seldom possible to tell the cotton of one country from the cotton of another by that means. On the other hand, no method is so efficient for determining the number of turns that the fibres contain as the microscopic method.

Mercerised Cotton. So far we have been dealing with normal cotton, but it is well known that a very large amount is sold in a mercerised condition today. When cotton has been thus treated, it does not look like raw cotton under the microscope.

Mercerising consists in steeping the cotton yarn in a strong bath of caustic soda, which treatment causes each individual fibre to swell up until it is almost round [3]. The typical twisted appearance almost disappears because the surface becomes smooth. In consequence, each fibre reflects a great deal more light, and the yarn assumes a lustre almost equal to silk, which it somewhat resembles in microscopic structure.

Treatment with a strong solution of this powerful chemical does not injure cotton or the cellulose of which it is composed. Mercerising actually strengthens the fibre and the yarn by 30 per cent. On the other hand, acids have a disastrous effect upon cotton. They combine with the cellulose in such a way that if the cotton is baked, it turns into a black hydro-cellulose, which is so brittle that it falls to powder. In this way a cloth composed of cotton and wool may easily have all the cotton taken out of it, without the least injury to the wool, and the treatment gives one of the simplest means of ascertaining the amount of each fibre present in a fabric.

The Variations of Wool Fibre. It is quite a common thing to hear intelligent people talk about wool as if all the various breeds produced exactly similar fibres. As a matter of fact, the same breed in two different countries will produce quite different wool, and if we examine the different breeds that exist in various parts of the world, we shall find that they contain fibres that vary as widely as human hair differs from rabbit fur. Wool fibres resemble the trees of a forest in their dissimilarities from each other, and also in their similarities. Some fibres are ten times as thick as others, some are long, and some short; some have smooth bark, some have rough bark.

Their internal structure also differs, but in every case the stem of the tree is of wood. The parallel is true also of wool. The chemical constituents of all wool (and, for that matter, of all hair and horn and quills) are very nearly identical, but the student must not jump to the conclusion that all wool fibres will look alike under the microscope. Just as cotton and all the vegetable fibres consist of cellulose, so wool, in common with all other animal fibres such as silk and hair, is composed of nitrogenous albumenoids. These substances take the form of albumen, casein, and fibrine. The actual state of the chemical combination of these substances is so complex that it has not yet been cleared up fully by chemists, and with this very brief reference the subject must therefore be dismissed.

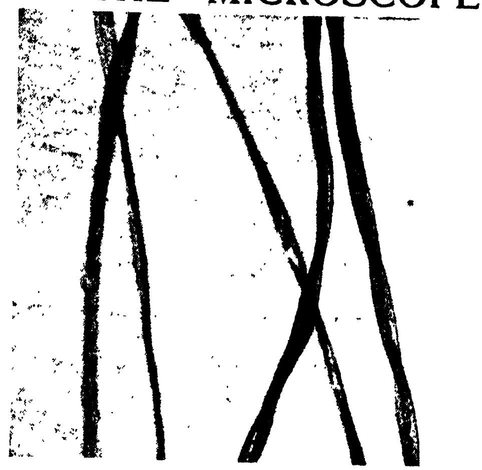
Effect of Caustic Soda on Wool. There is, however, one simple chemical fact of great interest with which everyone ought to be acquainted. The same caustic soda solution which is used to mercerise cotton, and thereby strengthen it, will dissolve wool entirely in ten minutes [4]. A very weak solution of many alkalis—notably sodium sulphide—will attack the outer covering of wool fibres in the space of a few minutes, and dissolve it even more quickly than caustic soda [5].

Caustic soda will peel away the scales or bark first, and will expose the spindle-shaped cells [8] of which the core of the fibre is seen to be composed when viewed under a glass of high magnification. On the other hand, acid which will carbonise and break up cotton has no detrimental effect on wool. It is true that concentrated sulphuric acid will attack wool in time—a space of several hours is needed—and it is the most useful of all the agents in setting free the various cells of which the fibres are composed [6].

Serrations in Wool Fibre. There is, however, one thin in which all wool fibres are alike, and in which they differ from all other fibres,

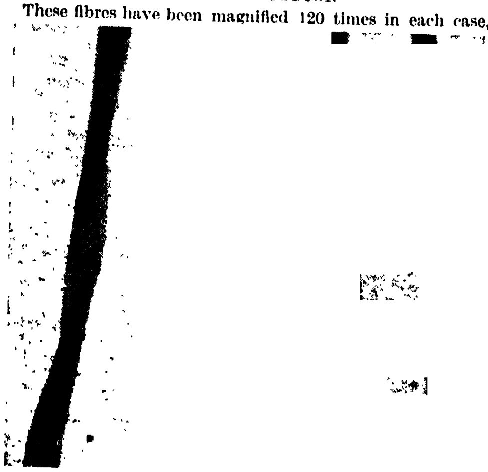
TEXTILE FIBRES UNDER THE MICROSCOPE

EGYPTIAN COTTON



AMERICAN COTTON

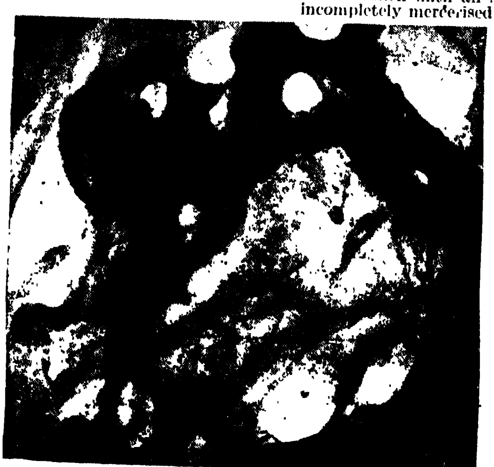
These fibres have been magnified 120 times in each case, and show that there is less twisting in the Egyptian type



FIBRES OF MERCERISED COTTON

WOOL PARTLY DISSOLVED IN CAUSTIC SODA

In the left-hand picture two fibres are swollen until all signs of twisting have disappeared, while that on the right is incompletely mercerised and shows a slight twist.



EFFECT OF SODIUM SULPHIDE ON WOOL

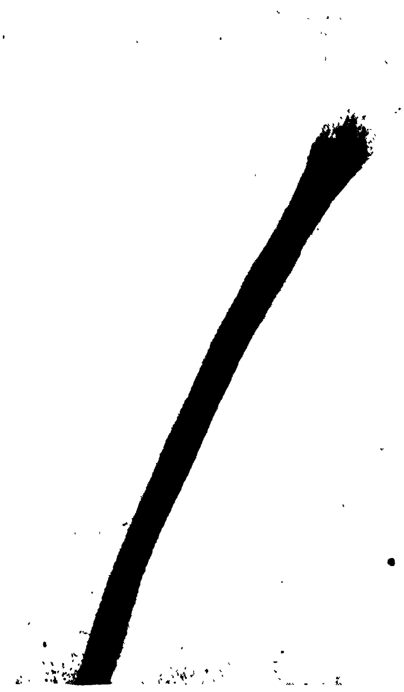
EFFECT OF SULPHURIC ACID ON WOOL

In the left-hand picture wool has been steeped in a strong solution of sodium sulphide for three minutes. In the right-hand picture fine botany wool has been steeped for 24 hours in concentrated sulphuric acid, the very high magnification showing the disintegrated, spindle-shaped cells.

They are covered on their outer surfaces with cells which take the form of scales. These scales differ very greatly in different types of wool. In all the lustrous fibres, such as mohair, alpaca, lustre wool, and demi-lustre wool, they are relatively large, and the edges do not protrude to any appreciable extent. At the other end of the scale come the fine merino wools, which might well be likened to small trees with rough bark, for they are covered with an enormous number of small scales, or plates. About these scales there is much difference of opinion, but the fact remains that in fine qualities of wool the edges farthest from the root of the fibre always protrude slightly, so that when the fibre is seen in profile, it has sometimes the outline of a saw [7]. It is an unfortunate fact that early microscopic investigators were unable to take photographs of what they saw, and they relied on drawings of fibres to illustrate their works. In some of these illustrations it cannot be denied that there was great exaggeration in the way the scales were shown. But because this mistake was made, there is no reason to go to the other extreme, and to say, as some writers have said, that the scales do not exist.

The real fact is that the refraction which was previously mentioned makes it difficult to see them unless the fibres are properly mounted, for it must be remembered the finest wool fibres are only $\frac{1}{1500}$ in. in diameter, an average 60's quality being about $\frac{1}{1000}$, and therefore any roughness on the surface must necessarily be of very small dimensions. As a matter of fact the depth of the serrations varies only between $\frac{1}{30000}$ and $\frac{4}{30000}$ in.

7. FINE MERINO WOOL
Showing scales and saw-like serrations at a magnification of 230 times



8. RUPTURED END OF KEMPY FIBRE
Showing spindle-shaped cells protruding at a magnification of 80 times

Serrations and Spinning Value. This in itself gives such a slight roughness to the fibre that anyone is justified in supposing that it cannot possibly affect the spinning value. Whether this is so or not, is still rather a doubtful question. But, at the same time, there is no doubt that wool is the only material that will mill or felt, and as wool is the only fibre that has serrations, the one is very naturally put down as being the cause of the other. The theory is that the teeth of the different fibres interlock, and when they are so held together, the action of the soap and water used to assist the process causes the fibres to revert as much as possible to their original curly condition. In other words, curling of the fibre causes the shrinkage in wool goods when the fibres are prevented from moving on one another by the serration on their surfaces.

An excellent supplementary proof of this fact is afforded by the means which are adopted to prevent certain wool goods from shrinking. Chlorine is always used in some form or other for this purpose, and treatment with chlorine invariably affects the fibres in such a way that the scales no longer protrude. It is for this reason that chlorinated goods do not shrink in washing. The wool fibres doubtless try to revert to their original curly condition, but as they have now no protruding serrations on their surfaces, they move freely without contracting the fabric which they go to form.

HOWARD PRIESTMAN

The Superior Planets. The Mystery of Mars. The Asteroids. Jupiter. The Rings of Saturn. Uranus. Neptune.

EARTH'S OUTER NEIGHBOURS

THE *superior* planets, all more distant from the sun than the earth, include five major planets—Mars, Jupiter, Saturn, Uranus, and Neptune—as well as a vast number of minor planets, of which nearly 600 are known at present. These outer planets differ from the inner planets, Venus and Mercury, in the nature of their apparent motion. Instead of oscillating backward and forward across the sun, they all move, on the whole, steadily westward in respect to the sun's place in the heavens, and consequently rise earlier and come earlier to the meridian every night. It is obvious that they can never pass between us and the sun as the inferior planets do at the time of transit.

The superior planets may appear in any part of the Zodiac, outside the limits of which, however, they never move. This is due to the fact that they all move round the sun in elliptical orbits outside that of the earth. When a planet lies beyond the sun in a straight line with the earth, it is said to be in *conjunction*; when the three bodies are in a straight line, but the planet is on the opposite side of the earth to the sun, it is said to be in *opposition*. Of course, we can never see the planet in conjunction, because it is only above the horizon in the daytime, when the light of the sun obscures it. The superior planets can be best studied when they are in or near opposition, because at such times they are nearest to the earth, and are also most favourably illuminated. They do not display phases like those of the moon. A necessarily brief account of the physical features of these various planets will now be given.

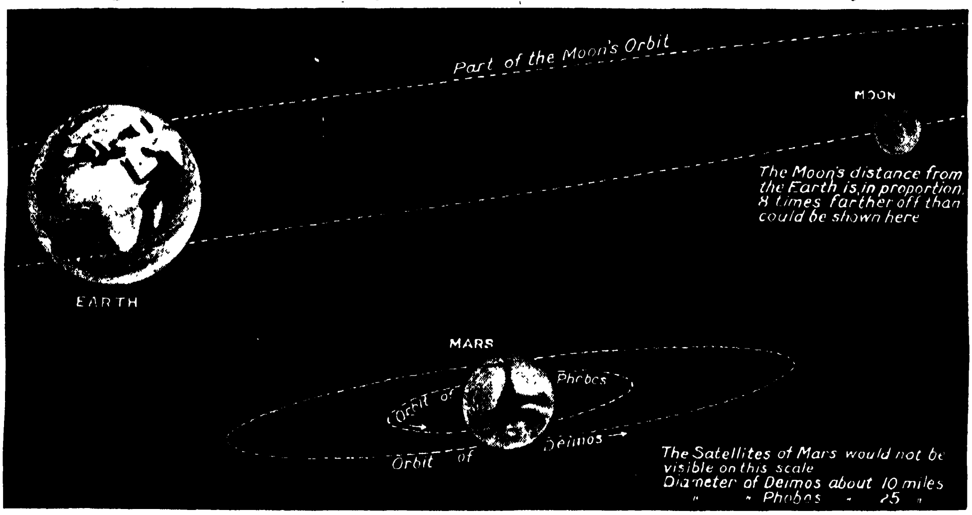
Mars, the major planet nearest to the earth, with the single exception of Venus, resembles the earth more closely than any other of the planets, and is most favourably situated for our observation of all the heavenly bodies, except the moon. It is a globe rather more than half the size of the earth, its diameter being about 4200 miles. Its mean distance from the sun is 141,500,000 miles, but the eccentricity of its orbit is so considerable that this distance varies by more than 26,000,000 miles. When Mars comes nearest to the earth its distance from us is about 35,000,000 miles. At these favourable moments its brightness is about equal to Jupiter, and only surpassed by that of Venus. Mars has a very pronounced red colour, which is supposed to be due to the prevalence of a rock like our red sandstone on its surface, or possibly to the colour of its vegetation.

When it is carefully studied through a powerful telescope Mars reveals itself as having a physical constitution very like that of the earth. It undoubtedly possesses an atmosphere, though this is much less dense than that of the earth, so that clouds are of very infrequent occurrence in it. Mars also possesses free water, which is collected into seas on its surface and gives rise to extensive caps of ice around its poles. These ice caps are observed to dwindle in summer, and increase in winter, so that their nature can hardly be doubted. The surface of Mars is divided, like that of the earth, into continents and oceans. The most peculiar feature in its land is the presence of numerous straight narrow markings which are commonly known as canals. They are not indeed canals such as we make on the earth, for they must be at least 60 miles in width in order to be visible to us at all. But there is little doubt that they represent watercourses of some kind.

The most curious thing about these canals is that they are not always visible. They seem at times to disappear from sight and then again reappear, and this in accordance with the periodical changes in the Martian seasons. It has been plausibly suggested that the marks which we see are not the actual watercourses, but the broad belts of vegetation which come into existence when the water is turned on to irrigate them, and die when it ceases to flow. It has even been suggested that this periodical flow and cessation of water is due to the enterprise of the

hypothetical inhabitants. At present this theory rests on inference, but there is a great deal to be said in its favour, and the astronomers who have studied Mars most closely are most nearly convinced of its truth. We know that Mars, being an older planet than our own, is farther advanced in evolution, and that it has reached the stage at which efforts far greater than any which mankind is yet called upon to put forth must be necessary for the preservation of life on its surface. Its water supply is already becoming scanty, and some gigantic system of irrigation would undoubtedly be necessary for its surface to continue fruitful. It is possible that the markings which we call canals do really represent such a system of irrigation, but we can hardly say more than this about the great problem of the existence of life in this planet.

Satellites of Mars. Mars has two satellites, which were only discovered as recently as 1877, although their existence and many of their characteristics had been strangely predicted by Swift in "Gulliver's Travels" more than 150 years earlier. They are exceedingly small, swift, and close to the planet. The outer one revolves at a distance of 14,600 miles from the centre of the planet in a little more than 30 hours, while the inner one is at a distance of only 5800 miles, and revolves in 7 hours 39·25 minutes. Mars itself rotates in 24 hours 37½ minutes. Consequently, its inner satellite completes more than three revolutions in every Martian day. To a Martian observer it will appear to rise in the west and set in the east, completing its apparent revolution in about 11 hours; for, of course, it revolves in the same direction as that in which the planet rotates. It is impossible to estimate the size of such a tiny object with any accuracy, but we can be sure that neither of the satellites is more than 30 or 40 miles in diameter, and probably they are even smaller than this. Mars completes its revolution round the sun in 687 days—nearly twice the time of the earth.



THE SYSTEM OF MARS AND ITS MOONS CONTRASTED WITH THAT OF THE EARTH AND MOON

In this diagram the markings on the earth and Mars are to scale, the orbits of the planets are seen in perspective, and the measurements are according to Prof. Lowell.

The Minor Planets, or Asteroids. The space between Mars and Jupiter is occupied by a strange and numerous swarm of *minor planets* or *asteroids*. The first of these singular bodies was discovered by an Italian astronomer, Piazzi, on the first night of the nineteenth century. Three others were discovered within the course of the next seven years, and the number now known is upward of 600, most of which have been recognised by the record of their motion on photographs of the sky. The four asteroids first discovered, Ceres, Pallas, Juno, and Vesta, are naturally the largest, ranging in diameter from 400 to 118 miles.

Vesta, though not the largest, is considerably the brightest of the minor planets, and is occasionally visible to the naked eye. None of the other asteroids has a diameter so great as 100 miles, and probably the majority of them are only 10 or 20 miles in diameter—mere "mountains broken loose," as they have been called. Most of these planets move round the sun in orbits which lie between those of Mars and Jupiter, and all of which intersect one another. There are a few exceptions to this rule, notably in the case of Eros, discovered in 1898. The orbit of this planet lies between Mars and the earth, and it is by far our nearest neighbour after the moon, its minimum distance from the earth being 13,500,000 miles. So close an approach will occur in 1931; it gives Eros a particular importance, as observations of it made at such a time should enable us to determine the solar parallax with greater accuracy than has hitherto been achieved. It was formerly supposed that these minor planets were the disrupted fragments of a planet which had been blown to pieces by some internal convulsions. It is now held, however, that they are more likely to be the remains of part of the original nebula which never coalesced into a planet.

Jupiter. By far the largest of the planets is the giant Jupiter, which is more than twice as

massive as all the other planets put together. Its mean diameter is 88,000 miles, and its mass is about 317 times that of the earth, though its mean density is not much greater than that of water. Its mean distance from the sun is about 483,000,000 miles, or rather more than five times the earth's distance, which is taken as the astronomical unit. It completes its revolution round the sun in 11 years 10 months, though it appears to revolve round the earth in a synodic period of 399 days. Jupiter is the brightest of all the planets except Venus, which, though much smaller, is much nearer to us and better illuminated. Jupiter rotates on its axis in rather less than ten hours, so that a point on its equator must be travelling at the rate of seven or eight miles per second. Its surface varies considerably from time to time, as seen through a telescope, and it is consequently concluded that what we see is really a surface of clouds. The great size and small density of Jupiter have led astronomers to believe that it is still in a condition somewhat akin to that of the sun—that is, that it has not yet solidified into a planet like the earth. Its temperature must be very great, though it is not so hot as to give out any perceptible light of its own. The most important marking on its surface is the great red spot which has been visible more or less in the same place since 1878, but no satisfactory explanation of the character of this spot has yet been given.

MARS AS SEEN WHEN NEAREST TO THE EARTH

Jupiter has at least eight satellites, four of which are large enough to be seen with a good field-glass, and were among the earliest discoveries made with the telescope of Galileo. The fifth satellite was discovered by the great Lick telescope in 1892, and is very much smaller than the others; the sixth and seventh were discovered by Professor Perrine at Lick Observatory in 1904–5. In 1908 Mr. Melotte, of Greenwich Observatory, discovered by photography the eighth satellite, which moves in a very eccentric orbit, and revolves in the contrary direction to the other satellites of the planet.

Saturn. Saturn is the outermost of the planets visible to the naked eye, and known to the ancients. Its mean distance from the sun is about nine and a half times that of the earth, or 886,000,000 miles. It is the second largest of the planets, being about 72,700 miles in diameter. Its mass is 95 times that of the earth, and its

TWO SKETCHES OF JUPITER AT AN INTERVAL OF THREE YEARS, SHOWING THE CLOUD-BELTS AND THE GREAT RED SPOT, WHICH IS OVAL IN SHAPE

mean density is only two-thirds that of water, so that the whole planet would float if it could be immersed in a vast ocean; hence, like Jupiter, it is supposed to be still in a largely gaseous condition. Its supply of heat and light from the sun is less than one-ninetieth of that received by the earth, and at its great distance the sun can only appear as a peculiarly brilliant star. Saturn rotates on its axis in about 10 hours 14 minutes, and takes 29½ years to complete its revolution round the sun. Its synodic period of apparent revolution round the earth is 378 days.

Saturn's Rings. Saturn is the most remarkable of the planets, and one of the most beautiful telescopic objects in the heavens, by reason of the wonderful system of *rings* with which it is girdled. When favourably visible from the earth it appears like a globe surrounded by three flat thin concentric rings lying in the plane of its equator. These rings revolve round the planet, and their plane always remains parallel to itself. It has been proved that the rings are not a solid structure, but consist of swarms of tiny meteorites, like the shooting stars which occasionally flash into our atmosphere. They must form a wonderfully beautiful spectacle if they could be seen from the surface of the planet which they adorn—a vast arch of light stretching from side to side across the sky and brilliantly illuminated through a great part of the planet's night. In addition to these rings, Saturn has no less than ten satellites, the largest of which is about half the size of the earth. With one exception they revolve in the same plane as the rings.

SATURN WITH ITS RINGS OPENED OUT TO THEIR MAXIMUM

Uranus. The two outermost of the planets were not known to the ancients. Uranus was the first planet discovered in modern times, being found by Sir William Herschel, in 1781, while he was sweeping the heavens with a seven-inch reflecting telescope of his own construction. It had frequently been observed before, but had always been mistaken for one of the fixed stars. But when Herschel saw it he recognised by the visible disc which it presented that it must belong to the solar system, and following observations proved that it was a planet lying beyond Saturn. Its mean distance from the sun is 19·2 times that of the earth, and it completes a revolution in its vast orbit in 84 years. Uranus can occasionally, on a moonless night, be made out by a very keen eye, as a star of the sixth magnitude, and certain early traditions about an eighth planet are supposed to imply that its true nature had thus been perceived by the very primitive astronomers. Its mass is about 14·6 times that of the earth, and its density is not quite double that of water. Little is known of its physical constitution; even its diameter has not been measured with any certainty, though it is probably about 30,000 miles. Uranus has four satellites, and possibly faint rings like those which encircle Saturn. From spectroscopic observations, Professor Lowell has estimated the period of rotation at 10 hours 45 minutes.

The Discovery of Neptune. The discovery of Uranus was a happy accident, but that of Neptune was the greatest triumph of mathematical astronomy since the time of Newton. After the orbit of Uranus had been fully calculated, it was found that the actual motion of that planet did not quite agree with prediction. The only valid explanation was that there must be an unknown planet still further from the sun than Uranus, whose attraction drew that planet away from its predicted motions.

Shortly before the middle of the nineteenth century, the problem of determining the place of such a planet from the trivial disturbances which it caused in the motions of Uranus was independently attacked by two astronomers—Adams, of England, and Le Verrier, of France. They both succeeded in solving it about the same time, though it was the calculations of Le Verrier which first enabled Galle's telescope to be pointed to Neptune, in 1846. The discovery of this planet was a remarkable confirmation of the truth of Newton's theory of the planetary movements under the law of gravitation.

Neptune. Neptune can just be seen with a good field-glass. Its mean distance from the sun is about 2,800,000,000 miles, and it takes 165 years to complete its orbital revolution. Its diameter is probably about 30,000 miles, and its mass is about 17 times that of the earth. Its density is about equal to that of Uranus—one-third that of the earth. Nothing is known of its rotation or physical constitution. It lies on the confines of the solar system, and if it were inhabited—which seems impossible—the sun would look to its people no bigger than Venus at her nearest approach to the earth, though the light which it gave would still be equal to that of 700 full moons. Neptune has one satellite, whose motion is even more irregular than that of the satellites of Uranus.

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THE MOST STRIKING SCENE IN THE HEAVENS

SATURN AS SEEN FROM JAPETUS, THE MOON WHICH IS NOT IN THE SAME PLANE AS THE RINGS

Levers, including Air-pump and Spring Levers, Cranks and Eccentrics, Wheel-gearing and Cams. Wedges and Screws.

MECHANICAL ELEMENTS APPLIED

We now give a number of selected examples of mechanism illustrative of the application of the skeleton force diagrams which were embodied in the last article. The levers there shown are simply the lever crank chains of Reuleaux, and the arms are the links turning about permanent centres. The skeleton lines have no relation to the actual shape of the mechanisms, they simply give relations, ideas, as evidenced by the differences in an engine beam, a crank, a toothed wheel, an eccentric, and so on. The student should exercise his faculties in tracing out the elements of mechanics through other diverse forms.

Examples of the Lever. Levers of the so-called first order [1, page 1027] occur most frequently. The most familiar form after the common pair of scales is that of an engine beam, in which the arms are equal on each side of the fulcrum, or central pivot, and the loads equally balanced; that due to the steam pressure on one side, and the resistance offered by the connecting-rod and fly-wheel on the other. As the greatest stresses come on the beam at the centre, due to the *leverage* exerted by the arms, the double parabolic outline is adopted, a form which, varied with plain tapered outlines, recurs constantly. Such a lever is subject to forces tending to snap it off near or through the fulcrum, and therefore the thickness of metal, in cast iron, has to be very liberally proportioned. Such beams have frequently broken after years of service. A terrible colliery accident once resulted from such a beam breaking. In the older engines, timber was used largely; in modern practice, mild steel plates are used for beams, large and small alike, two or more being laid parallel, with distance pieces intervening.

Air-Pump Lever. An unequal-armed beam, a lever of the first order, is illustrated in **15**, being an air-pump lever for an engine of marine type. The usual proportion for such levers is 2 to 1—that is, the air-pump piston has just half the stroke of the engine piston. The load upon the pump end of the lever is found by multiplying the area of the pump piston or bucket by 30 lb. per square inch. This latter figure makes allowance for the various frictional resistances as well as the load due to suction, and so on. Then, applying the principle of the lever, the load on the engine end is

$$\frac{\text{Area of pump piston} \times 30 \times A}{B}$$

A being the distance of the pump end from the pivot fulcrum, and B being the distance of the engine end from the fulcrum. The pins, bearings, and rods can then be designed to suit the resulting loads. The fulcrum pin has to sustain both loads as well as the weight of the work itself.

Cranks. An engine crank [**16**] is one of the most familiar examples of the same group of levers. But here one arm is absent, so that it is a disguised form. But the deficient arm is provided by the resistance which is set up in the engine shaft by the driven mechanism, and which the crank has to overcome. A crank shaft is therefore subjected to severe torsion, just as though a massive weight were suspended from an arm attached to its circumference. The crank disc [**17**] is exactly the same element, as is clearly seen by the outlining of a crank on its face. The disc form has nothing to do with the twisting stress on the shaft, but the circular shape is imparted in order to obtain a counterbalance to the crank to enable it to rotate without a jerky movement, a counter-balance which does not exist in **16**.

The bent crank in **18** is another example of a one-armed lever, the resistance to which is embodied in the crank shaft. As such cranks are liable also to jerky movements, they are often counterbalanced by other leverages. Thus, to counterbalance locomotive cranks, heavy weights are inserted in the driving wheels opposite to the crank pins. Two-cylinder compound marine engine cranks [**19**] often have weights formed as extensions of their webs. But for these provisions, locomotives would knock themselves to pieces when running, and compound marine engines would be subject to excessive vibrations.

Often the one-armed crank is balanced by other similar cranks in the same mechanism. Thus a pair of engines are set with their cranks not in line, but at right angles, or sometimes diametrically opposite. Treble-barrel pumps have their cranks [**20**] arranged in the three-throw style, or at angles of 120°, to balance each other.

An eccentric [**21**] is a crank, and therefore a lever, only the fact is disguised by the *throw*, and by the fact that the equivalent of the crank *pin*, instead of being of relatively small diameter, as in **16-20**, is larger than the combined diameter of the shaft, plus double the eccentricity. The relation of the lever crank is indicated in the figure by the two small circles, centre of *throw* and of rotation respectively.

The Tower Bridge Levers. Going from smaller to larger examples, the great lifting bascules of the Tower Bridge are levers of the first order. Only one arm of each bascule is seen, the other is hidden within its pier. The arms are of unequal length, the shorter being in the piers, but equality of moments is produced by increasing the mass of the shorter arm.

there, and adding counterweight, so that the long and short arms balance.

The application of the lever of the first order [p. 1025] to the common balance is obvious. But it is applied to a large number of weighing machines in which the arms are not equal, including the public weighing engines of the streets and platform weighing machines. An enormous disproportion is made between the long and short arms, and thus a very slight depression at one end is multiplied many times at the other, and communicated to the steelyard—another lever in the office.

Foot Brake. The second order of levers has a typical example shown in 22—*viz.*, a foot lever brake for an ordinary steam crane. The load on the brake band is, first of all, calculated by multiplying the pull by the diameter of the lifting barrel or drum, and dividing by the diameter of the brake band. The lifting drum in the example is 9 in. in diameter, the brake band 2 ft. 6 in., and the pull on the drum is 2 tons:

$$= \frac{2 \text{ tons} \times 2240 \text{ lb.} \times 9 \text{ in.}}{30 \text{ in.}} = 1344 \text{ lb.}$$

Only a portion of this comes upon the end of the strap that is operated by the lever. The exact amount depends upon the arc of contact which the strap makes with the brake drum, and upon the co-efficient of friction between the band and the drum. With a co-efficient of ·02, and an arc of three-fourths of a circle, the load will be approximately ·64 of the above sum = 1344 × ·64 = 860 lb. Then, by the principle of the lever, the load on the foot treadle is

$$\frac{860 \times 2{\cdot}5 \text{ in.}}{42 \text{ in.}} = 51 \text{ lb.}$$

With a brake of this class, it is necessary to balance the treadle and lever so as to ensure the brake being released freely when the pressure is removed from the treadle. This is accomplished by forging an extension to the lever and securing a counterweight thereon, the amount of which can be calculated by treating the case as a lever of the first order.

The construction of brakes of this class generally utilises the friction between wood—elm or poplar—and cast iron. The brake blocks are made in widths of from 3 to 4 in., and screwed to a strap of thin sheet iron, which makes a flexible element, capable of being wrapped both freely and tightly round the turned rim of the band-wheel. The lever, being subjected to severe bending stress, is a forging, and the counterbalance weight is generally cast with a hole to slide over the opposite end of the lever, to be fastened to it with a set bolt.

Axle-turning Head. An excellent example of a lever of the second order is shown in the drive of the Armstrong-Whitworth axle-turning lathe [23]. The fulcrum is at one end in the centre (A) of the axle which is being rotated. The power is at the opposite end, at the pitch line of the toothed wheel (B) which rotates the axle, and the weight or load is at the circumference of the axle, which is being turned by a cutting tool there. The smaller the axle, therefore, the greater is the mechanical gain.

Power is gained also for turning the wheel by another lever, the driving pinion at the back (not shown) making with the wheel a pair of levers of the first order [p. 1025]. The pins (*CC*) standing out from the head are a Clement's driver, employed to produce equal driving movements about the axle being turned. Lathe men will recognise this as the familiar device adopted to balance the driving effort, and so prevent one-sided jerky movements of work about the centre.

Clip. The third order of levers is not nearly so much in evidence as are the first and second. Having no mechanical advantage, it finds applications only under peculiar conditions. An example is given in 24, in the form of a clip, that is used to prevent certain portions of machinery from revolving, and which is a useful detail when fitted to a derrick gear worm on a crane. The power to be exerted by the hand wheel and screw is, of course, determined by multiplying the pressure required on the clip by the distance A, and dividing by the distance B.

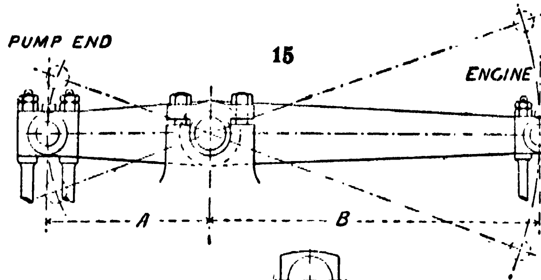
The illustration also shows the application of a screw (C) operated by a lever, the hand wheel (D) to gain sufficient power on the clip to overcome the turning movement of the worm gear. Here, as in the case of the lever [22] with long and short arms, enormous mechanical advantage is obtained by the exercise of the power of one man.

Clasp Nut. Fig. 25 is a familiar example of a lever of the same order—the Whitworth clasp nut. The hinged levers (A A) have the nut portions attached at one end (in the form of half-brasses), while the power to operate them is derived from the cam plate (B), the pins of which transmit power. The cam plate is attached to the lever (C), the handle (D) of which extends to the front of the lathe.

Spring Levers. There is a large number of levers in every order in which a spring is the element of either power or weight. They occur in the treadles of some forms of power hammers, and in the automatic trips of many machine tools.

Fig. 26 shows a lever trip of one kind applied to the reversing motion of a grinding machine. The rod (A), being moved by a dog at a certain stage of the table travel, throws the fork (B) and its clutch in either one or other direction, so putting the bevel wheels shown into engagement. To retain them thus, the spring plunger (C) has its end bevelled to match a bevel on one arm of B. The plunger is forced up as B pivots by the coiled spring behind it, when the bevelled faces lock.

Force Pump. Levers are made with movable fulcrums to suit different pressures, as, for example, in 27, where an ordinary hydraulic force pump is shown. Two fulcrums (A and B) are arranged by fitting a removable pin to the two holes in the framework. The short arms of the leverage available measure 6 in. and 3 in.



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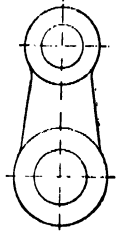
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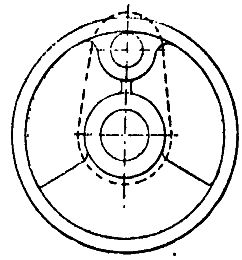
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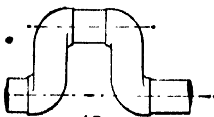
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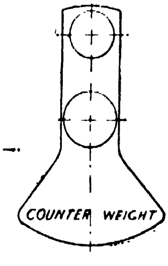

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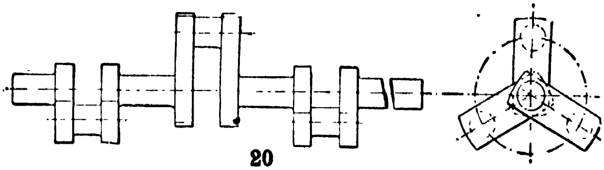
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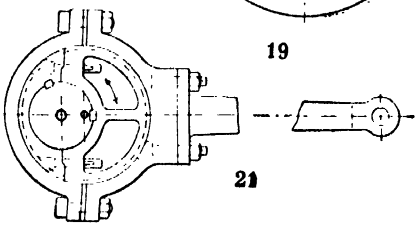
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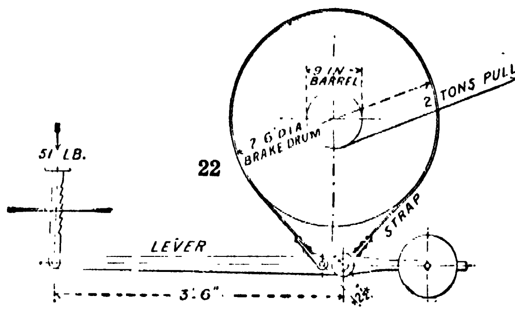

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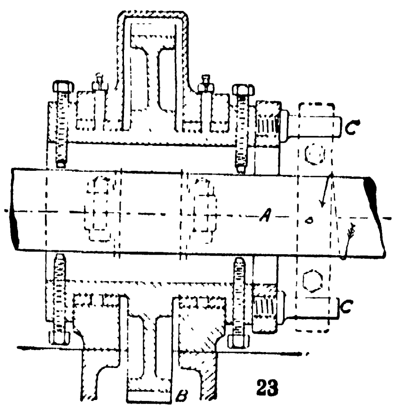

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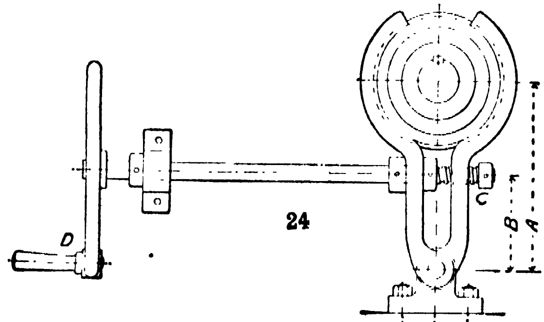

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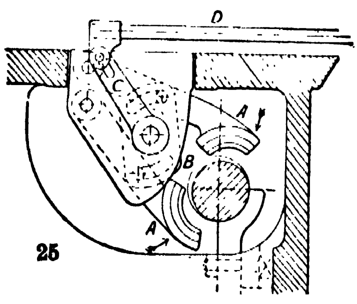

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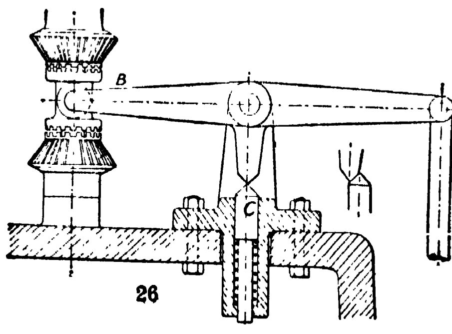

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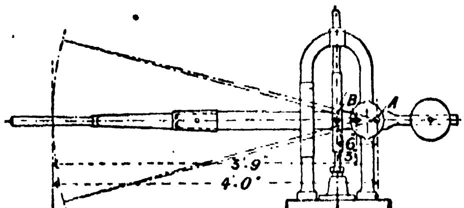
PRACTICAL APPLICATIONS OF THE LEVER



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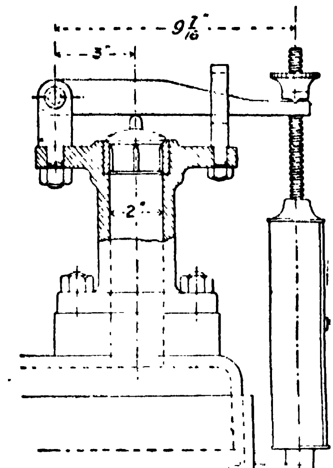

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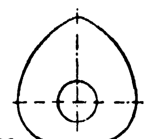

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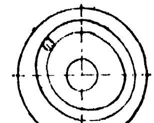

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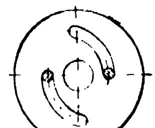

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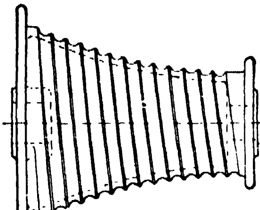

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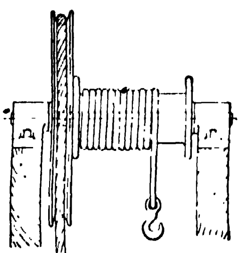

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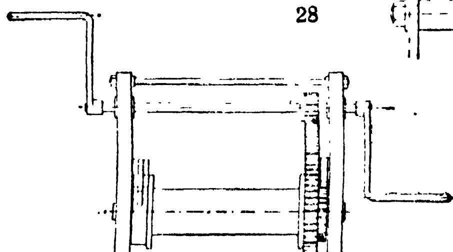

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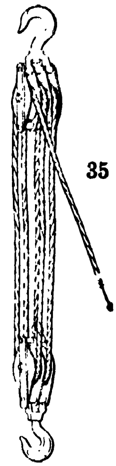

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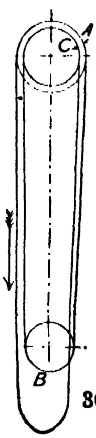

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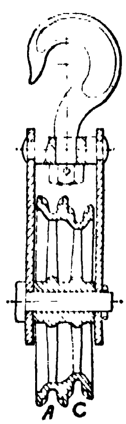

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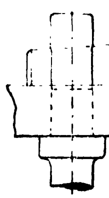

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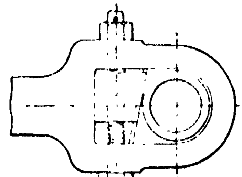

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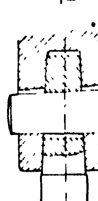

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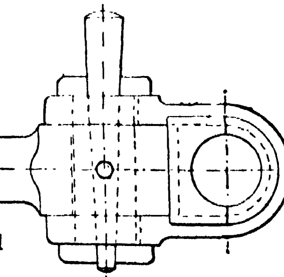

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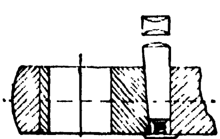

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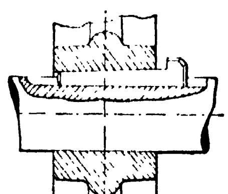

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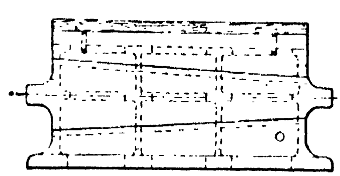


44

PRACTICAL APPLICATIONS OF THE LEVER AND WEDGE

respectively, and the long arms 48 in. and 45 in. respectively. When working on fulcrum A the mechanical advantage is $\frac{48 \text{ in.}}{6} = 8$ to 1. When the pressure rises and the work becomes harder, the fulcrum pin is moved to B, and the mechanical advantage becomes $\frac{45 \text{ in.}}{3} = 15$ to 1, the stroke of the pump ram being correspondingly shorter.

Safety Valve. A case where a lever is designed to give the load per square inch upon a given area is illustrated by the spring-balanced safety valve in **28.** The valve is 2 in. in diameter, and the spring of course records pounds. The proportion of the lever depends upon the area of the valve. If the valve were 1 sq. in. in area it is manifest that the recording spring could be placed directly over the valve, or fitted on a lever of equal proportions. If the valve was 2 sq. in. in area a lever of 2 to 1 would be required. A 2 in. diameter valve is 3·14 sq. in. in area, and so the lever is arranged in the same ratio. Fixing the fulcrum at 3 in. from the valve centre, the lever becomes 3 in. $\times$ 3·14 = 9·42 = $9\frac{7}{16}$ in. long. The spring safety valve is an alternative design to that, having a lever arm loaded with a weight.

Wheel Gearing. Toothed gears are disguised levers ; the teeth are only incidents, since smooth-faced wheels will run by friction. It is not necessary even that the radii should be constant, but radii and leverage may vary. And thus we have elliptical gears, triangular gears, square gears, and others, all transmitting variable but constantly recurring rates of motion.

It is an axiom in kinematic chains that they may be converted into mechanisms in as many ways as they have links, because any one link may be made the fixed one, leaving the others movable. This can be studied in the spur gears, which are levers, or turning pairs connected by means of the teeth, which in theory have line contact. In ordinary wheels the centres are fixed by bearings, and the rigid connection thus imposed is a mechanical link. There is no motion of the centres in space. In what are termed epicyclic trains, only one centre is thus fixed, and one or more revolve round it in one direction or the other, with a minute gain or loss in speed.

Cams. A cam is a lever, but with its arms of varying lengths, corresponding with the outlines imparted to the edge or groove, as the case may be. The centre on which the cam rotates is the fulcrum to the edge or grooves. In cams the lengths of arm vary, changing from maxima to minima, or passing through variable but irregular movements. In the modern practice of the engineers' machine shop they fill a place of constantly increasing importance, inasmuch as they take the place of movements otherwise effected by the hands of the workman, with more or less inaccuracy. The cam is both tireless and precise. Its movements can be relied on, for they are timed in the design itself. In feeding movements especially, the cam is of most value. It is embodied notably in the various automatic screw machines for controlling the relative movements of the tools and work.

Fig. **29** is a heart cam, giving variable but regular movements on each lobe. Fig. **30** is a grooved-face cam, giving an irregular motion, and Fig. **31** is the regular two-slot cam plate for clasp nuts, etc., another example of which occurs in **25.**

Fusee. In the fusee barrel [**32**] we have another example of a variable leverage, resembling the cams in this respect. But the object in this case is to maintain uniformity derived from variable movements, not only in horological instruments, but in cranes. In the latter, in the jibs of derricks which pass from greater to less radii, and *vice versâ* from the perpendicular, the fusee drum keeps the load at a uniform height.

Tension Organs. The wheel and axle, like its primal mechanical element, occurs in very many forms. The principle [**5,** page 1027] is the putting of a rope on or around a large pulley (lever) by which the weight is drawn up on a smaller "axle" (pulley, drum, or lever). This device lends itself to many applications. These form one of the great groups termed by Reuleaux *tension organs.* In other words, they only operate in tension, being useless in compression. They owe a part of their great value to their flexibility, which feature permits of changing the directions of motion. Several materials can be utilised for tension organs, as ropes, chains, wire, and belting in its various forms. In some types of hand hoists, for warehouse work, the form occurs almost absolutely [**33**], the load being lifted by a rope coiled around a small drum, while the endless chain or rope is pulled round the large one. This is also employed in many hand travellers.

The Whip Crane. The whip crane affords another literal example, the load being lifted by a small drum, and the chain or rope pulled round a large one. The slight differences are that the large drum is more correctly described as a double-flanged pulley, and the rope is tied through a hole in one flange and coiled round the pulley by means of a winch on the post below. In hand-travelling cranes operated from below, the rope or chain is fitted around its rim in recesses to "bite" with sufficient gripping power to prevent slip from occurring.

The winch handle of a crane corresponds with the "wheel" in **5.** Its radius is fixed at from 15 to 16 in., because this is as far as a man can conveniently reach. But the diameter of the "axle"—the chain drum or barrel—can be made as small as 6 or 8 in., gaining much power, with corresponding reduction of speed of lift. The smaller the diameter of the drum the greater the mechanical advantage. In practice, this device of altering diameter is often adopted in hoisting machines of less simple character, a set of gears, for example, being retained, and a smaller or larger drum inserted to suit requirements.

But few hoisting machines are so simple as to comprise only the winch handle and drum. The power gained would be totally insufficient for

the lifting of heavy loads. In the simple crabs [34] and some small cranes, the first advance on this device occurs. The winch handle is not put on the same shaft as the drum, but on another lying parallel therewith, and the two shafts are "geared" together by means of toothed wheels (levers) of unequal radii, the smaller, actuated by the winch handle, directly actuating the larger on the same axis as the drum. The mechanical gain then is

$$\frac{\text{radius of winch handle} \times \text{radius of wheel}}{\text{radius of pinion} \times \text{radius of drum}}$$

Further, this "simple train" gives place in large cranes to compound trains, in which two or more such combinations exist, and the gain is

$$\frac{\text{radius of winch handle} \times \text{radii of all wheels}}{\text{radii of all pinions} \times \text{radius of drum}}$$

In power-operated cranes, the winch handle is abandoned for the higher pressure agency of steam, water, or that derived from the electric motor. Then, in many cases, trains of gears are diminished in number, or even abandoned in favour of a direct drive.

Pulley Blocks. In the diagrams of certain pulley blocks already given, care was taken to state that the results were secured only by neglecting friction. That was necessary in order to grasp first principles. It is simply an expression of the law that the mechanical work given out by a mechanism would be equal to that put into it, if there were no such thing as friction. But as friction does exist, it happens that every additional element in a machine adds its own quota of friction—more or less severe—to make up a big total, until in one particular case, that of the differential pulley block, substantially **9** (page 1027), the load will remain suspended in any position. This could not happen in **6** and **7**. It happens in **9**, solely by reason of the gross total of friction.

The mechanical advantage, therefore, in either of these diagrams, is not that of power and weight simply, but of these plus more or less of friction. that of the cords or chains around their pulleys, and of the pulley pins in their bearings. In the application of all the elements now under discussion, the designer strives to lessen friction as far as possible, but in another set he turns friction to practical account.

Fig. **35** shows a set of pulley blocks in which the combinations **8** to **10** are embodied in a practical manner by putting the sets of pulleys side by side on the same axis. Any height of lift can be obtained by these by giving enough length of rope. Fig **36** is a diagram of the differential block, which also embodies the principle of the Chinese windlass. The chain is pulled round the large pulley (A), passing thence to the snatch-block pulley (B) below, thence it returns and winds round the smaller pulley (C). As A and C are cast together [**37**], the result must be that the snatch-block is lifted by a space equal to the difference in the circumference of A and C. The chain is prevented from slipping by nibs cast in the sheaves, and the friction—due to the different diameters of A and C—equals more than half the power expended, the load therefore remaining suspended without braking. When it has to be lowered, the opposite side of the chain must be pulled on. The lifting rate is, of course, extremely slow.

Inclined Plane. This occurs in the cableways that play so large a part in the haulage or transport of material. The ropes used are the inclined planes, and the suspended skips or buckets are the loads. Power is applied by ropes, but economy is often studied by making one bucket, or set of buckets, in their descent, serve to draw up another on another incline.

Wedges. The wedge occurs in many forms, in some as a splitting agent, in others as a means of tightening parts. As the first, its best exponents are seen in cutting tools, and if it be objected that these hardly come within the scope of applied mechanics, we must point to the immense importance of the cutting instruments which are embodied in machine tools, and around which these are built. As these will have full treatment in the later course on TOOLS, attention is here drawn only to the bare fact.

Cottars. The second group includes cottars and allied forms, which device is employed in many bolts, also in the strap form of connecting rod ends, in effecting rapid union of long lengths of pump rod, of long roof ties, and very much besides. The cottar takes various forms in these examples [**38-42**].

The cottar pure and simple is driven by a hammer, but in the form of a tail of a bolt [**42**] it is tightened by screwing the nut. The angle or taper of the wedge is an important detail, not only in cutting tools but in the cottar. If the angle is too large in a driven cottar, the effect of jar on the mechanism will be to loosen it, by causing it to work back out of its seating, hence the set screw in **41**. It is therefore made as drawn [**38-42**]. A cottar bolt may have more taper because the nut holds it against the influence of jar. The value of the cottar in these cases lies in the provision which it affords of taking up wear in the brasses, to be considered at length in the course on MACHINE DESIGN. Thus we have the function of the cottar as a convenient method of union, and also that of effecting minute compensation for wear.

Keys. The common key [**43**] is a wedge, cousin-german to the cottar. It secures wheels on their shafts by a wedging action pure and simple, and its taper is but slight, to prevent risk of slackening back. The forms of keys do not concern us here, as they are dealt with in MACHINE DESIGN, but their relation to the wedge is properly noted.

Keel Blocks. Passing to the massive, we see in the row of keel blocks [**44**] under a vessel on the stocks a simple means of adjustment. Three wedge pieces, of cast iron, the upper one carrying a piece of teak wood plank, sustain a share of the load of the vessel during construction. By hammering the middle piece farther in or out the height of the block is readily varied, and with it the level of the mighty mass above. The angle is very small, otherwise no effect could be produced, the

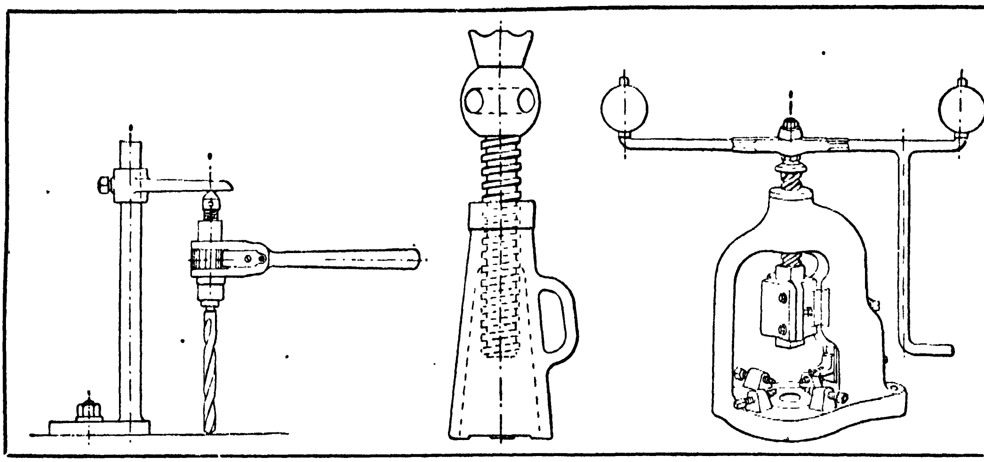
reason for which was given in connection with **14** [page 1028]. Another familiar application of the wedge is to pile driving. The pile, pointed, its bottom end shod with steel, is driven by the the monkey into sand and clay.

Screws. The screw occurs in hundreds of combinations, both as an instrument for gaining mechanical advantage, as a means of fastening, or as a precision instrument, so that one is rather at a loss what examples to select.

One of the most striking yet commonplace examples of the first is the screw-jack, and allied forms, such as the John Bull, the fly-press, the copying-press, and the pile screw. We call them allied, because, though their functions are dissimilar, their method of action is the same—the exercise of immense force through a very small space, with a small expenditure of power exercised through a large space. One man can, by operating the screw by a lever, lift a load into the body, two or three threads are run side by side of the same pitch, which thus results in a stronger body and a larger thread surface to withstand wear.

The Pile Screw. The pile screw is an application of the same kind to the turning of iron piles into the beds of rivers. It is capable of penetrating not only sand, but gravel, clay, and broken rock. The movement is slow. It is produced, generally, by employing another screw and lever in the form of worm gears, a worm wheel encircling the head of the pile and being turned by a worm, actuated by hand or engine.

The propeller embodies segments of a screw of quick pitch. That is, if the screw were completed, the distance between threads would usually be from 18 to 24 ft. But then the movement of propulsion would be slow but for the fact that the shaft to which the propeller is attached is driven at a rapid rate.



45. JOHN BULL SCREW AND LEVER **46.** SCREW-JACK **47.** FLY-PRESS

of several tons by the screw-jack [**46**]. A man using the John Bull [**45**], which is a simple screw and lever, can drill holes an inch in diameter in iron and steel. The fly-press [**47**] is essentially a double-ended lever operating a double-threaded screw of quick pitch, for stamping pens, tinned ware, medals, and much besides. The copying-press is an allied form operated similarly. In these elementary machines the gain in power and its compensating loss in speed are obvious. The screw being simply an inclined plane wound round a cylinder, the smaller the angle of the incline the greater the power gained. Therefore, in the screw-jack and the John Bull, the screws are of what is termed fine pitch, or low pitch, or flat pitch. In other words, their angle is low, and consequently the number of turns or threads in a given length is large. But when speed of movement is required, with moderate power, they are of quick pitch, or sloped very much. This is the case in the fly-press [**47**], where momentum is necessary, to be obtained only by a screw of rapid traverse, or of considerably more slope than that imparted to the screw-jack. And as a single thread of coarse pitch would cut too deeply

Conveyor screws have no end-long motion themselves, but they transmit that motion to loose stuff shot into them. Corn, cement, or other pulverised material is compelled by its own inertia to be carried along by the blades of the continuous screw, and at a rate which is controlled by pitch and rate of revolution.

The screw, as a means of measurement, occurs in the lead screws of lathes. It is the first element in cutting screw threads in this machine tool. Though of one unvarying pitch, it controls the cutting of hundreds of other possible pitches by the change wheels—variables introduced between the screw and the mandrel of the lathe. The same element is found in the universal milling machine, in the screws of micrometer calipers, and in the Whitworth measuring machine. We cannot here trace the screw into the numerous worm, spiral, and helical gears, which are treated in the later course on MACHINE DESIGN. The same observation applies to toothed gears and other mechanisms mentioned in these papers, but the design and proportioning of which belong properly to the subject of MACHINE DESIGN.

JOSEPH G. HORNER

Defective and Impersonal Verbs and Oratio Obliqua in Latin. Continuation of English and German.

LATIN

Continued from page 1032

By Gerald K. Hibbert, M.A.

SECTION I. GRAMMAR

Frequentative Verbs. These express repeated or intenser action, and are formed either (1) in *-to*, *-so*, from supine stems—*e.g.*, *tracto* = I handle (from *traho*, *traxi*, *tractum* = I draw); *curso* = I run about (from *curro*, *cucurri*, *cursum* = I run); or (2) by adding *-ito* to the last consonant of the present stem—*e.g.*, *rogito* = I ask often. All Frequentatives are first conjugation.

Inceptive Verbs. These express beginning of action, and are formed by adding *-sco* to the present stem of verbs, or from nouns by adding *-asco* or *-esco*—*e.g.*, *juvenesco* = I begin to grow young; *ignesco* = I burst into flame. All these are third conjugation.

Desiderative Verbs. These express desire, and are formed by adding *-urio* to the supine stem—*e.g.*, *esurio* = I am hungry (from *edo*, *esum* = I eat). All these are fourth conjugation.

Quasi-Passive Verbs. These are the exact opposite of Deponents. Deponents are passive in form and active in meaning; Quasi-Passives are active in form and passive in meaning—*e.g.*, *fio* = I am made; *exulo* = I am banished; *liceo* = I am put to auction; *vapulo* = I am beaten; *veneo* (compound of *eo* = I go) = I am on sale (used as the passive of *vendo* = I sell).

Defective Verbs. These lack some of a verb's usual parts:

1. *Odi* (I hate), *memini* (I remember), *cœpi* (I begin), are perfects, without any present-stem tenses. *Novi* (I know), from *nosco*, is similarly used. Thus: "To hate" = *odisse*; "I remembered" = *memineram* (pluperfect).

Memini has Imperative *memento*, *mementote*.

Cœpi and *odi* have perfect and future participles—*cœptus* and *cœpturus*, *osus* and *osurus*.

2. Many verbs have perfect without supine, and some have neither perfect nor supine—*e.g.*, most of the Inceptive verbs.

3. *Inquam* (I say) has the following parts:

	1.	2.	3.
Present:	inquam	inquis	inquit
	inquimus	inquitis	inquiunt
Imperfect:	—	—	inquiebat
	—	—	inquiebant
Future:	—	inquies	inquiet
Perfect:	—	inquisti	inquit
Imperative:	—	inque	—
	—	inquite	—

Aio (I say ay, I affirm) has:

	1.	2.	3.
Present:	aio	ais	ait
	—	—	aiunt
Imperfect:	aiebam (complete)		
Pres. subj.:	—	aias	aiat
	—	—	aiant

Fari (to speak)—deponent—has: *Fatur* (he speaks); *fabor* (I shall speak); *fare* (speak thou); *fari*, *fatus*, *fandus*.

Impersonal Verbs. These are conjugated only in the third person singular of the finite verb, and in the infinitive. They can be in any tense.

1. The following are used with the accusative: *Oportet* (it behoves), *decet* (it beseems), *dedecet* (it misbeseems), *piget* (it irks), *pudet* (it shames), *poenitet* (it repents), *taedet* (it wearies), *miseret* (it moves pity)—all second conjugation; also, *delectat* (it charms), and *juvat* (it delights)—first conjugation.

2. The following are used with the dative: *Libet* (it pleases), *licet* (it is lawful), *liquet* (it is clear)—second conjugation; also, *accidit*, *contingit* (third), *evenit*, *convenit*, *expedit* (fourth).

Examples: *Oportet me ire* = I must go. *Licuit tibi ridere* = You were allowed to laugh.

3. *Pudet*, *piget*, *taedet*, *poenitet*, *miseret*, are used with an acc. of the person feeling, and a genitive of what causes the feeling: *Taedet me vitae* = I am weary of life. *Tui me miseret*; *mei piget* = I pity you; I am vexed with myself.

4. *Interest* and *refert* (it concerns, or it is important for) take the *genitive* of the person concerned—*e.g.*, *Caesaris interest pontem facere* = it is Cæsar's interest to build a bridge. [This construction is rare with *refert*: say, *ad Cæsarem refert*.] But *possessive pronouns* are used in the *ablative feminine*—*e.g.*, *Quid meā refert* = What does it signify to me? *Magis nullius interest quam tuā* = It concerns no one more than yourself*.

Irregular Verbs: First Conjugation. The following are the most important exceptions:

Perfect—*ui*. Supine—*itum*.

crepo crepare crepui crepitum *creak*

* The *meā* and the *tuā* probably agree with *re* understood. *Meā re fert* was originally *meae rei fert*, and then *rei* being shortened to *re*, *meae* became *mea*. If this is so, *mea interest* is probably an imitation.

Similarly, *cubo* (*lie down*), *domo* (*tame*), *plico* (*fold*), *sono* (*sound*), *tono* (*thunder*), *veto* (*forbid*).

Perfect—*ui*. · Supine—*tum*.

seco	secare	secui	sectum	*cut*

Perfect reduplicated. Supine—*tum*.

do	dare	dedi	datum	*give*
sto	stare	steti	statum	*stand*

Perfect—*vi*. Supine—*tum*.

juvo	juvare	juvi	jutum	*help*
lavo	lavare	lavi	lotum *or* lavatum	*wash*

NOTE. Compounds of *do* are of third conjugation, and make *-didi*, *-ditum* (except *circumdo*, *pessumdo*, and *venumdo*, which make *-dedi*, *-datum*). Compounds of *sto* form *-stiti*, *-stitum*.

SECTION II. COMPOSITION

The Oratio Obliqua. This construction, known also as Oblique Narration, or the Accusative and Infinitive Construction, is one of the most characteristic idioms of Latin. It is especially used where English has a clause beginning with *that* after (1) verbs of *saying*, *knowing*, *thinking*, *believing*, *feeling*; (2) impersonal expressions, as "It is clear, true," etc.

Rule 1. The subject is put in the acc. case, and all principal verbs are changed from indicative to infinitive, retaining their original tenses—*e.g.*, He says that the moon is smaller than the sun = *dicit lunam esse minorem sole* (literally, He says the moon to be smaller). I know that I shall die = *scio me moriturum esse.*

[Instead of *dico . . . non*, Latin uses *nego* = I deny—*e.g.*, He said he did not believe = *negavit se credere.*]

Rule 2. All verbs, other than principal verbs (*i.e.*, verbs directly making a statement), are put in the subjunctive. There cannot be an indicative in Oratio Obliqua. This is very important.

Examples: "The slaves whom I now have here are most faithful" is in Oratio Recta (Direct Narration), and would be in Latin, "Servi quos nunc hic *habeo* sunt fidelissimi." Turn this into "reported speech," or Oratio Obliqua, and we have "He said that the slaves whom he then had there were most faithful" = dixit servos quos tum ibi *haberet* esse fidelissimos. [Note the change of "now" into "then," "here" into "there," "I" into "he," "have" into "had." and "are" into "were"; but we still use "esse" for "were," because "esse" is both present and imperfect infinitive, and "fuisse" would mean "had been."] Again, "It is clear that, because the citizens are cowards, the city will be taken" = manifestum est quod cives ignavi *sint*, urbem captum iri.

Rule 3. Imperatives in Oratio Recta become imperfect subjunctive in Oratio Obliqua—*e.g.*, *Recta*: "Charge, my men," said the general = *Instate, milites, inquit imperator. Obliqua*: "The general said to his soldiers, 'Let them charge,'" = imperator militibus dixit, Instarent.

Rule 4. Questions in the first and third persons are rendered in Oratio Obliqua by the accusative of the person and the infinitive of the verb; but questions of the second person become imperfect or pluperfect subjunctive—*e.g.*, (They said) Why is our general absent? = *cur abesse imperatorem?* (He said) Why are you advancing? = *cur progrederentur?*

Rule 5. *Ego*, *tu*, *nos*, *vos*, cannot find a place in Oratio Obliqua; *me* and *nos* become *se*, *tu* becomes *ille*, and *vos* becomes *illi*.

Se and *suus* refer, as a rule, to the speaker—*e.g.*, He says that he will come = *dicit se venturum esse.*

He said, "Let them not forget his kindnesses" = *ne suorum beneficiorum obliviscerentur.*

If, however, *suus* is wanted to refer to the subject of some subordinate verb (*e.g.*, *obliviscerentur*, above), then *ipse* is used to refer to the speaker—*e.g.*, Let them not forget their own cowardice or his kindnesses = *ne suae ignaviae aut ipsius beneficiorum obliviscerentur.*

NOTE. The translation of the English conjunction *that* needs great care. When it means "in order that," "so that" (as "He walked fast that he might warm himself"), it should be translated by *ut* with subjunctive. When it means "the fact that," after any verb or phrase *sentiendi vel declarandi* ("of feeling or stating") the accusative with the infinitive must be used. In English we can say, "You were ill, he thought, and therefore absent." But in Latin we must say, "He thought that you were ill, etc." (*Putavit te aegrotare*).

TO BE TURNED INTO LATIN PROSE.

The inhabitants of this island were so bold that they would have preferred a thousand deaths (*say*, "to die six hundred times") to disgrace, if the choice had been necessary. One brave farmer was asked why he would sooner die nobly on the field of battle than live ignobly at home. He answered, "Because I am more afraid of shame than of death." It happened once that they were invaded by the powerful nation of the Ventidii, who landed on their shores, marched up to their capital, devastated the country all round, and then laid siege to the city. The citizens determined to resist with boldness. Instead of throwing themselves at their enemies' feet, they sent away their families, their old men, and their treasures, and prepared to resist with desperation. Though they were prevented by scruples from committing suicide, they promised one another to fight so desperately that the enemy should not take them alive. When they were all assembled in arms, their general addressed them thus: "Remember, citizens, that victory or death awaits you. I will say no more; the enemy is at the gates. What reason is there for delaying?"

LATIN VERSION OF THE ABOVE EXTRACT.

[Latin prose composition can be learned only by long and constant practice. The student is advised to translate the following Latin version *literally* into English, and then compare his English version with the English version as given above. This will give him a good idea of the difference between the English and the Latin ways of expressing ideas. Accuracy and clearness are the first essentials, and then the style should be polished by constant comparison

with the style of the best Latin authors, such as Livy and Cicero. Hints on style will be given from time to time during the remainder of this course.]

Qui in hac insula habitabant ii omnes quum essent summa audacia præditi, sescentiens mortem quam semel, si optandum fuisset (*gerundive* = "if it had to be chosen, if choice had to be made") infamiam obire maluissent. E quibus agricola quidam, vir fortissimus, rogatus cur potius vellet militiæ per virtutem emori quam per dedecus domi vivere, respondit se ignominiam magis quam mortem timere. Quibus ita accidit ut Ventidii, quæ gens erat potentissima, in eorum fines navibus ingressi, agris undique vastatis, urbem quam maximam habebant obsiderent. Sed quum civibus visum esset sibi quam acerrime hostibus obstandum (gerundive), tantum aberat ut se iis ad pedes dejicerent ut, pecuniis et liberis et senibus dimissis, sese ad resistendum accingerent ut (as) qui de suis rebus desperarent. Religione quidem obstricti quominus sibi mortem consciscerent, alii tamen aliis pollicebantur sese acrius pugnaturos quam qui ab hostibus vivi caperentur. Quos quum armatos imperator convocasset (shortened form of *convocavisset*), jussit meminisse aut victoriam aut mortem obeundam: se non plura dicturum; hostes illis ad portas adesse: quid causæ (partitive genitive, literally "what of reason") esse cur jam morarentur?

Section III. TRANSLATION

Peroration of Cicero's Second Philippic Speech.

Respice, quæso, aliquando rempublicam, M. Antoni: quibus ortus sis, non quibuscum vivas considera: mecum, ut voles: redi cum republica in gratiam. Sed de te tu videris: ego de me ipso profitebor. Defendi rempublicam adolescens, non deseram senex: contempsi Catilinæ gladios, non pertimescam tuos. Quin etiam corpus libenter obtulerim, si repræsentari morte mea libertas civitatis potest: ut aliquando dolor populi Romani pariat, quod jam diu parturit. Etenim si abhinc annos prope viginti hoc ipso in templo negavi posse mortem immaturam esse consulari, quanto verius nunc negabo seni? Mihi vero, patres conscripti, jam etiam optanda mors est, *perfuncto** rebus iis quas adeptus sum quasque gessi. Duo modo hæc opto; unum ut moriens populum Romanum liberum relinquam—hoc mihi majus ab dis immortalibus dari nihil potest—alterum, ut ita cuique eveniat ut de republica quisque mereatur.

* "Perfuncto" is dat. of the perf. ptc., agreeing with "mihi": it governs an abl., being compound of "fungor."

English Version of Above.

Bethink yourself of the State, I beseech you, even now, Marcus Antonius: think of those from whom you have sprung, not of those with whom you now associate: deal with me as you like, but make up your quarrel with the State. About your own course, however, you yourself will decide: I will openly profess my own. I defended the State in my youth, I will not abandon it in my age: I scorned the swords of Catiline, I will not fear yours. Nay, rather, I would gladly offer my body, if by my death the freedom of the State can be immediately recovered, so that at last the pangs of the Roman people may give birth to that with which they have so long been in travail. If, nearly twenty years ago, I said in this very temple that death could not be untimely for one who had filled the consulship, how much more truly shall I say this now of an old man! For me indeed, Senators, death is even to be desired, now that I have completed the course of honour and of achievement.

I have only two wishes. One is that at my death I may leave the Roman people free—and no greater gift than this could be granted me by Heaven! The other is that as each man has deserved of the State, such may be that man's reward.

Continued

ENGLISH

By Gerald K. Hibbert, M.A.

THE VERB—*continued*

Strong and Weak Conjugations. English verbs are divided into *strong* and *weak*, according to the manner in which they form their Past Indefinite tense.

1. Verbs that form this tense by modifying the vowel of the present tense (without adding any suffix) are said to belong to the *strong* conjugation—as: *shine, shone.* The past participle of all strong verbs originally ended in *-en*, and this ending still remains in many of them (sometimes in the form of *-n*)—as: *break, broke, broken.* The past tense of strong verbs arises from contraction of the original reduplicated form; for this tense was at first formed by reduplication—*i.e.*, by repeating the root of the verb (*cf.* in Latin, *fallo, fefelli,* where the reduplication modifies the root vowel from *a* to *e*). With a few exceptions, all strong verbs are of one syllable only. The exceptions are really compounds of simple verbs, as *forget, beget, awake, abide*, etc.

2. Verbs that form their past indefinite by adding the suffix *-ed*, *-d*, or *-t* to the present tense are said to belong to the *weak conjugation*—as: *treat, treated*; *feel, felt.* When the present tense ends in *e*, *d* only is added—as, *love, loved.* The vowel *y* preceded by a consonant becomes *i* before this suffix—as: *bully, bullied*; *pay, paid.* A single final consonant preceded by a single vowel is usually doubled before the suffix—as: *drug, drugged*; *travel, travelled.* The

past participle of weak verbs is usually the same in form as the past indefinite. If the present tense ends in *d* or *t*, the suffix is often dropped, and present, past, and past participle have all the same form—as: *cost, cost, cost.*

All the verbs in the Strong Conjugation are of old Teutonic stock. The Weak Conjugation, while including some old verbs and some that were once Strong, is mainly composed of the verbs added at later times—*e.g.*, at the Norman Conquest. Every new verb now added to the language belongs to this conjugation—as: *telephoned, motored, electrified, photographed.*

It is needless to give here a list of all the Strong and the Weak Verbs in the English language. The most interesting verbs, however, and those that present any difficulty, are now given.

Verbs of the Strong Conjugation.

1.

Present.	*Past.*	*Past Participle.*
bind	bound	bound
find	found	found
grind	ground	ground
cling	clung	clung
fling	flung	flung
sling	slung	slung
slink	slunk	slunk
stick(*a*)	stuck	stuck
string	strung	strung
swing	swung	swung
wring	wrung	wrung
begin	began, *or* begun(*b*)	begun
drink	drank, *or* drunk(*b*)	drunk, *or* drunken(*c*)
ring	rang, *or* rung(*b*)	rung
sing	sang, *or* sung(*b*)	sung
sink	sank, *or* sunk(*b*)	sunk, *or* sunken(*c*)
spin	span, *or* spun	spun
shrink	shrank, *or* shrunk(*b*)	shrunk, *or* shrunken(*c*)
spring	sprang, *or* sprung(*b*)	sprung
stink	stank, *or* stunk(*b*)	stunk
	swam, *or* swum (*b*)	swum
win	won [old form, *wan*]	won
wind	wound	wound

NOTES. (*a*) *Stick*, now strong, was formerly weak.

(*b*) These forms are not often used now.

(*c*) *Drunken, sunken,* and *shrunken* are now used only as adjectives—as: a *drunken* man; *sunken* rocks; *shrunken* flannel.

2.

Present.	*Past.*	*Past Participle.*
blow	blew	blown
grow	grew	grown
know	knew	known
throw	threw	thrown
draw	drew	drawn
hold	held	holden, *or* held
fall	fell	fallen
lie (to recline)	lay	lain
slay	slew	slain
see	saw	seen
drive	drove [old form, *drave*]	driven
ride	rode	ridden
rise	rose	risen
smite	smote	smitten
chide	chid [old form, *chode*]	chidden, *or* chid
hide	hid	hidden, *or* hid
slide	slid	slidden, *or* slid
strive	strove	striven
strike	struck	stricken, *or* struck
thrive	throve	thriven
write	wrote	written
bite	bit	bitten
eat	ate	eaten
beat	beat	beaten
bid (*to order*)	bade, *or* bid	bidden, *or* bid
give	gave	given
forsake	forsook	forsaken
shake	shook	shaken
take	took	taken
come	came	come
bear	bore, *or* bare	borne, *or* born
break	broke, *or* brake	broken
tear	tore, *or* tare	torn
wear	wore	worn
weave	wove	woven
speak	spoke, *or* spake	spoken
steal	stole	stolen
swear	swore, *or* sware	sworn
choose	chose	chosen
freeze	froze	frozen
fly	flew	flown

NOTES. *Fall, fell, fallen* is intransitive; but the kindred verb *to fell* is transitive, and regular of the weak conjugation—as: "The woodman *felled* the tree." *Bare, brake, tare, spake, sware* are not used in modern English.

Borne means *carried*; *born* is used of *birth*, chiefly after the verb "to be." Examples: "Which have *borne* the burden and heat of the day" (St. Matthew); "Where is He that is *born* King of the Jews?" (St. Matthew).

3.

Present.	*Past.*	*Past Participle.*
abide	abode	abode
awake	awoke	awoke
stand	stood	stood
tread	trod	trod, *or* trodden
sit	sat	sat
get	got (gat)	got (gotten)
hang	hung	hung
run	ran	run
burst	burst	burst
shoot	shot	shot
seethe	sod	sodden, *or* sod
spit	spat, *or* spit	spit
fight	fought	fought

NOTES. *Awake*, as a strong verb, is intransitive, meaning "I wake up." When it is transitive, meaning "I rouse some-one," it is weak, and has *awaked, awaked* for its past tense and past

participle. Similarly with *hang;* when intransitive it is strong—as: "He *hung* there for three hours"; when transitive, it is weak—as: "But he *hanged* the chief baker."

Seethe, meaning *to boil*, is very seldom used now, except in a figurative sense—as: "A seething mass of men." The original sense is seen in the expression, "And Jacob *sod* pottage" (Genesis). The past participle *sodden* now means "soaked through." *Seethe* is now usually weak, making *seethed, seethed.*

Verbs of the Weak Conjugation. 1. Some lose the suffix and shorten the vowel—as:

Pres.	*Past.*	*P.Part.*	*Pres.*	*Past.*	*P. Part.*
bleed	bled	bled	meet	met	met
breed	bred	bred	read	read*	read*
feed	fed	fed	speed	sped	sped
lead	led	led	light	lit	lit

* Pronounced *rĕd.*

2. Some lose the suffix without changing the vowel; but they change the final *-d* into *-t:*

Present.	*Past.*	*Past Participle.*
bend	bent	bent
lend	lent	lent
rend	rent	rent
send	sent	sent
spend	spent	spent
wend	went, *or* wended	wended
build	built	built, *or* buildbd
blend	blended	blent
gild	gilt, *or* gilded	gilt, *or* gilded
gird	girt, *or* girded	girt, *or* girded

3. Some lose the suffix and show no change at all. The following have the same form throughout: *Cast, cost, cut, hit, hurt, knit, let, put, rid, set, shed, shred, shut, slit, split, spread, thrust,* and *bid* (meaning "to offer at an auction," as "He *bid* £5 for it yesterday"). *Let,* meaning *to hinder,* comes from *lettan* (to hinder, *cf. late*), while *let,* meaning *to allow,* is from *laetan* (French *laisser*).

4. Some retain the suffix, but shorten or otherwise alter the vowel:

Present.	*Past.*	*Past Participle.*
beseech	besought	besought
buy	bought	bought
catch	caught	caught
bring	brought	brought
sell	sold	sold
seek	sought	sought
teach	taught	taught
think	thought	thought
tell	told	told
work	wrought	wrought
can	could	—
may	might	—
will	would	—
shall	should	—
bereave	bereft, *or* bereaved	bereft
creep	crept	crept
deal	dealt	dealt
dream	dreamt, *or* dreamed	dreamt
feel	felt	felt
flee	fled	fled
hear	heard	heard
keep	kept	kept
kneel	knelt	knelt
lean	leant, *or* leaned	leant
leave	left	left
lose	lost	lost
mean	meant	meant
sleep	slept	slept
sweep	swept	swept
weep	wept	wept
lay	laid	laid
say	said	said
shoe	shod	shod

Verbs of Mixed Conjugation. Some verbs are found in both conjugations, while others either combine a weak past participle with a strong past tense, or a strong past participle with a weak past tense.

Present.	*Past.*	*Past Participle.*
shear	shore	shorn
	sheared	sheared
climb	clomb	—
	climbed	climbed
cleave (= to split)	clove	cloven
	clave	
	cleft	cleft
heave	hove	hoven
	heaved	heaved
dig	dug	dug
	digged	digged
crow	crew	crowed
	crowed	
help	helped	holpen
		helped
hew	hewed	hewn
		hewed
lade	laded	laden
lose	lost	lost, lorn (as in *forlorn*)
melt	melted	molten
		melted
	mowed	mown
		mowed
	rived	riven
		rived
saw	sawed	sawn
		sawed
shape	shaped	shapen
		shaped
shave	shaved	shaven
		shaved
shew, *or* show	shewed, *or* showed	shewn, shown, *or* shewed, showed
sow	sowed	sown
		sowed
strew	strewed	strewn, strown
		strewed
swell	swelled	swollen
		swelled
wash	washed	washen
		washed

Present.	*Past.*	*Past Participle.*
wax	waxed	waxen
(= to grow)		waxed
do	did	done
go	[went]	gone

NOTES. *Went*, used as the past tense of *go*, is the past tense of *wend*—as in "to wend one's way."

Crew (from *crow*) is rarely used now, and only of the literal crowing of a cock—*e.g.*, "the cock *crew*." When used of the crowing of babies, etc., the past tense is always *crowed*.

Many of the above forms are now obsolete—*e.g.*, *holpen* ("He hath holpen his servant Israel"), *hoven*, *washen*, *waxen* ("The children of Israel were *waxen* strong"); and some of the past participles are used only as adjectives—*e.g.*, a *molten* image, the *cloven* hoof, a *shaven* head.

Clothe, *have*, and *make* form *clad*, *had*, and *made*, which are contracted from *clothed*, *haved*, and *maked*.

Tight, *straight*, *dight* (adjectives) are weak past participles of *tie*, *stretch*, *deck* (= to *adorn*). *Distraught* is an irregular past participle of *distract*. *Fraught* is sometimes said to be the participle of "to freight," but probably it is not connected with any verb.

"Lie" and "Lay." So much confusion is prevalent concerning these two verbs that a special paragraph seems needful in this connection. We can leave out of consideration *to lie*, meaning *to tell an untruth*; for this verb is of the weak conjugation and perfectly regular, *lie*, *lied*, *lied*.

Examples: "He *lied* like a trooper," "You have *lied* to me more than once."

The confusion arises between *to lay* and *to lie* (meaning *to recline*), because the past tense of *lie* in this sense is *lay*. Let us compare the principal parts of the two verbs.

Present.	*Past.*	*Past. Part.*
lie	lay	lain
lay	laid	laid

To lie is strong and *intransitive*; therefore, it cannot govern an object or be used in the passive voice. *To lay* is weak and *transitive*; therefore it must have an object expressed.

Examples: "He *lay* there for several hours," "I have never *lain* on a softer bed," "That hen *laid* an egg yesterday," "Having *laid* His hands upon them, He blessed them." Of course, we can say either "They *lay* down" or "They *laid themselves* down"; the meaning is practically the same in either sentence, but the verb in the first is intransitive, and in the second transitive (with *themselves* as object).

EXERCISE.

Correct, *if necessary*, the following sentences:

1. I will both lay me down in peace, and sleep.
2. We ought to lay down our lives for the brethren.
3. I am going to lay down.
4. He lied when he said that he had lain his work aside and had laid down all the afternoon.
5. Having lain motionless for some time, I began stealthily to creep along.
6. When he has laid his burden down, he will be a different man.
7. Lay here and rest; lay your head upon this pillow.
8. It has been laid upon me that I ought to go.

Continued

GERMAN

Continued from page 914

By P. G. KONODY and Dr. OSTEN

Gender of Nouns and Adjectives

XII. Of FEMININE GENDER are:

(*a*) Substantives denoting female persons [see VII. 1].

(*b*) Many animals of both sexes.

(*c*) Nouns ending in -ei, -eit, -schaft, -ung, and -ucht.

(*d*) The names of most trees, except compounds with Baum (*m.*) tree, which are always masculine [see XII. 2].

(*e*) Inanimate objects ending in -e.

(*f*) Such words ending in in as are formed from the correlative masculine by the addition of this suffix which denotes the female gender. (Masculine nouns ending in -e in this case drop this letter, and in some cases the stem vowel is modified.) Der König, the king; die König-in, the queen; der Graf, the count; die Gräf-in, the countess; der Löwe, the lion; die Löw-in, the lioness; der Hund, the dog; die Hünd-in, the bitch; der Franzo'se, the Frenchman, die Franzö's-in, the Frenchwoman [EXCEPTION: Der Deutsche, the German, die Deutsche (*not* die Deutschin), the German woman]; der Bauer, the peasant, die Bäu'er-in, the peasant-woman.

(*g*) The names of a few countries, which are always used with the definite article

EXAMPLES: (*a*) die Tochter, the daughter; die Schwester, the sister.

(*b*) die Lerche, the lark; die Hyäne, the hyena.

(*c*) die Schmeichelei', flattery; die Frei'heit, liberty; die Freu'ndschaft, friendship; die Eri'nnerung, remembrance; die Schlucht, the gorge, ravine.

(*d*) die Eiche, the oak (but der Eichbaum, the oak tree); die Pappel, the poplar; die Lärche, the larch; die Fichte, the pine.

(*e*) die Tinte, the ink; die Rose, the rose; die Güte, the kindness, etc. EXCEPTIONS: der Käse, the cheese; das Auge, the eye.

(*g*) die Türkei', Turkey; die Schweiz, Switzerland; die Krim, the Crimea; die Mol'dau, Moldavia; die Wallachei', Wallachia, and so on.

Of NEUTER GENDER are:

1. (*a*) All words which are not substantives, but are used substantively, and are therefore written with capitals.

(*b*) The names of some countries and towns, which take the article das when preceded by adjectives.

(*c*) All diminutives ending in -chen and -lein. [See VII.]

(*d*) Most nouns ending in -nis, -sal, and -tum.

(*e*) Many metals.

(*f*) The majority of collective nouns with the prefix Ge-.

EXAMPLES: (*a*) das Tanzen (infinitive of a verb with a capital), the (act of) dancing; das Erha'bene, the sublime (adjective used substantively): das Viel'fache, the manifold (indefinite numeral).

(*b*) das so'nnige Ita'lien, sunny Italy; das ne'belige England, foggy England; das unerme'ßliche London, immense London; das reiche Hamburg, rich Hamburg.

(*c*) das Brü'derchen (diminutive of der Bruder), das Mütterlein (dimin. of die Mutter), das Blü'melein or das Blümchen (dimin. of die Blume, the flower).

(*d*) das Hin'dernis, the obstacle; das Schick'sal, the fate; das Hei'ligtum, the sanctuary. EXCEPTIONS: die Ke'nntnis. (*f.*) the knowledge; die Drangsal (*f.*) the affliction, trouble; der Reichtum (*m.*) wealth; and a few others.

(*e*) das Eisen, iron; das Blei, lead; das Kupfer, copper; das Silber, silver. EXCEPTION: der Stahl, steel.

(*f*) das Gebir'ge, the mountain range; das Gefo'lge, the retinue; das Gewölf', the clouds, etc. But there are also many EXCEPTIONS; for instance: die Gemein'de (*f.*), the community; der Gesang' (*m.*), the singing, song.

2. COMPOUND NOUNS take their gender from their last component—*e. g.*, der Post'bote (*m.*) the postman, [die Post (*f.*) and der Bote (*m.*) messenger]; die Brief'taube (*f.*) the carrier-pigeon, [der Brief (*m.*) letter, and die Taube (*f.*) pigeon, dove]; das Gar'tenfest (*n.*) the garden-party, [der Garten (*m.*) and das Fest (*n.*) the festivity]. In some compound words an e or s is inserted for the sake of euphony.

3. COMPOUNDS OF ADJECTIVES OR PREPOSITIONS WITH SUBSTANTIVES generally take the gender of the substantive, but there are exceptions to this rule; for instance: die An'mut (*f.*) the grace, [der Mut (*m.*) courage]; die Sanftmut (*f.*) gentleness, tenderness [sanft, gentle, and der Mut]; der Ab'scheu (*m.*) the aversion, [die Scheu (*f.*) bashfulness]

4. A few substantives have two genders which can be used indiscriminately; for instance; der (*m.*) or das (*n.*) Me'ter (the metre), Liter (litre), Thermome'ter, Barome'ter, Scepter (sceptre); die (*f.*) or das (*n.*) Verderb'nis, corruption, depravity; der or die Hausflur, lobby, entrance hall; der or das Un'gestüm, impetuosity, and so on.

5. The following substantives change their meaning with the gender:

der Band (*m*) volume [of a book]	das Band (*n*) ribbon
der Bauer (*m*) peasant	das Bauer (*n*) [bird-] cage
„ Bund (*m.*) league	„ Bund (*n.*) bundle
„ Chor (*m.*) choral-song, or chorus	„ Chor (*n.*) locality in the church for the choir
„ Erbe (*m.*) heir	„ Erbe (*n.*) inheritance
die Erkenntnis (*f*) insight	„ Erkenntnis (*n*) judicial verdict
der Gehalt (*m.*) contents	„ Gehalt (*n.*) salary
„ Geißel (*m.*) hostage	die Geißel (*f.*) scourge
„ Haft (*m.*) clasp	„ Haft (*f.*) prison, custody
„ Harz (*m.*) Harz Mountains	das Harz (*n.*) resin, gum of trees
„ Heide (*m.*) heathen	die Heide (*f.*) heath
„ Hut (*m.*) hat	„ Hut (*f.*) heed, guard
„ Kiefer (*m.*) jaw	„ Kiefer (*f.*) fir
„ Kunde (*m.*) customer	„ Kunde (*f.*) news intelligence
„ Leiter (*m.*) manager, guide	„ Leiter (*f.*) ladder
die Mark (*f.*) province, boundary, Germ. coin	das Mark (*n.*) marrow
der Mensch (*m.*) man	„ Mensch (*n.*) wench, hussy
„ Messer (*m.*) measurer	„ Messer (*n.*) knife
„ Reis (*m.*) rice	„ Reis (*n.*) sprig, twig
„ Schild (*m.*) shield	„ Schild (*n.*) sign-board
„ See (*m.*) lake	die See (*f.*) sea
„ Sprosse (*m.*) offspring	„ Sprosse (*f.*) step of a ladder
die Steuer, (*f.*) rate, tax	das Steuer (*n.*) helm, rudder
der Stift (*m.*) pencil	„ Stift (*n.*) monastery, chapter
„ Teil (*m.*) part	„ Teil (*n.*) due, share
„ Thor (*m.*) fool	„ Tor (*n.*) gate
„ Verdienst (*m.*) gain, profit, earnings	„ Verdienst (*n.*) merit
die Wehr (*f.*) defence	„ Wehr (*n.*) weir, dyke,

EXERCISE. Insert the missing articles, verbs, and nouns. To avoid confusion, the German phraseology has been adopted for the English translation of German sentences, so that each word is under its German equivalent.

.... Tante redet mit .... Nichte; .... Schwester
The aunt speaks to the niece; the sister

..... Mädchens ist schön; ich liebe .... Eiche,
of the girl is pretty; I love the oak,

... Pappel, und ... Kastanien-Baum; ... Höflichkeit
the poplar, and the chestnut (-tree); the civility

...... Engländers ist bekannt; ... Erinnerung ist
of the Englishman is known; remembrance is

... Prüfstein (see VII. b and XII. 2) ... Vergangenheit;
the touchstone of the past;

.... Wiese war grün und .... Heide braun;
the meadow was green and the heath brown;

..... Käse ist frisch.
the cheese is fresh.

.... Fürst schreibt; .... lobte ....
the prince writes; the princess praised the

Kinder; .... Baron und .... kommen heute;
children; the baron and the baroness come today.

To be continued

Choosing Material. Style, Measurements, and Tools. The Drafting. Stitches. Stretching and Shrinking.

TAILORING FOR MEN

There are at least three distinct courses of study that have to be taken up by the young man who aspires to be a thoroughly qualified master tailor. He requires a knowledge of the practical or sewing part, the scientific or cutting part, and the commercial or business part.

Some little difference of opinion exists as to what is the proper order in which to take these. The old method was to serve a long apprenticeship to the sewing, then take lessons in cutting, and leave the business side to be picked up by actual experience—a plan which often led to the Bankruptcy Court, despite considerable technical ability. The more modern plan is to enter an academic course at some such institution as the "Tailor and Cutter" Academy, and there take lessons in all three sections simultaneously.

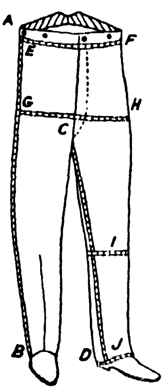
Assuming the customer has presented himself, the first step is to take the order, and here the skill of the tailor begins.

Selecting the Material. The material should be in harmony with the requirements of the customer, bearing in mind his occupation, form, and complexion. For wear-resisting purposes, cheviots, tweeds, and serges may be recommended; for dress garments, thinner, softer, and finer finished cloths are best. For business and professional wear, black coats and vests, and neat, striped trousers are generally most suitable. For farmers, builders, etc., neat drab tweeds of rather a heavy make, and not too rough, are the most appropriate.

For sportsmen, Harris tweeds and checked cheviots are very popular, and make up into stylish garments. Stout men should be dressed in dark colours, and plain or very small-patterned cloths. Checked cloths make men appear wider without increasing the appearance of height in proportion; and if checks are woven irregularly, as is sometimes the case, they give a lopsided effect which is anything but attractive. Stripes, whether in the pattern of the material, or produced by seams, stitchings, braidings, etc., add to the length or width of the figure in the direction in which they run.

Dark complexions are best suited by those shades in which reds and yellows play an important part—as, for instance, russet brown, drab, etc. Fair people are best suited by blues, and those shades in which blue plays an important part.

Sell your customer material adapted to his requirements on these lines, and then proceed to get particulars of style.



1. MEASUREMENTS

The Style. This includes the shape of the garment and its general finish, and here the tailor will receive great assistance from fashion plates.

Do not attempt to put a man with old-fashioned ideas into the latest cut; discretion, tact, and judgment must be exercised, or the result will be bad. Find out what your customer wants, and then advise him judiciously; and having determined the style, carefully book the details of his order as it relates to pockets, time for trying on, finish, price, etc., together with the number of the material, and then proceed to take the measures, beginning with the trousers.

Measurements. A to B, full length of side, say, 44; C to D, full length of leg, say, 32; E to F, circumference of waist, say, 30; G to H, circumference of hips or seat, say, 36; I, size of knee required, say, 18; J, size of bottom required, say, 17 [1].

It is seldom wise to give less than 12 in. extra length to the side than the leg. Avoid taking the waist measure tightly. Take the size of seat in harmony with your customer's idea of fit.

Cutting Tools. We now take our cutting tools—*viz.*, inch tape, square, chalk, shears, and, if possible, a trouser stick. Take the cloth from which the garment has to be cut, notice if there is a way of the wool, and if so arrange for the pile to run down. If there is a string in the selvedge, it indicates a flaw in the cloth which must be avoided in the cutting. [This point will be dealt with more fully later.] The cloth is cut double, and in order to cut for the right and left sides this is arranged face to face. As a rule, trousers are drafted direct on the cloth in this way:

The Drafting. 1—2, the selvedge edge of cloth; 1 to 2, the length of side = 44; 2 to 3, the length of leg = 32; 3 to 4, one-sixth seat = 6; 2 to 9, one-fourth bottom = $4\frac{1}{4}$ [2].

Draw line from 9 to 4, and by it square across to 3. Square by line 4 to 9 across to 6; 4 to 5, one-twelfth seat = 3; 4 to 6, one-sixth seat plus $\frac{1}{4} = 6\frac{1}{4}$. Square up from 5 by line 5 to 3 (which is at right angles to line 4–9). Square across from 7 to 1; 13 is one-sixth seat plus 4 in. up from 5 = 10; 13 to 14 one-fourth waist plus $\frac{1}{2}$ in. = 8 in.

Spring out a little above 14, and round out to side line about 3 or 4 in. up from 3; 4 to 8, half leg length less 2 in. = 14; 8 to 10 and 8 to 11 are each one-fourth knee = $4\frac{1}{2}$; 9 to 12, one-fourth bottom, less $\frac{1}{4}$ in.

Complete outline of top sides as shown. Hollow over the fronts about $\frac{3}{4}$ in., for a 17

bottom, more for a smaller and less for a larger bottom.

The top sides are then cut out, a " turn-up " of from 1 in. to 1½ in. being left at the bottoms. The " dress " is cut out from the right side as follows: 6 to 15, 1 in., curve up to fly line and down to leg seam as shown.

The Under Side. Lay down the cut-out top side and proceed as follows:

6 to B, 1½ in.; 10 to C, 1 in.; 12 to D, 1½ in.; 5 to A, one-fourth seat less 1 in. = 8. Draw line from 6 through A [3].

13 to 14 and F to G together equal half waist plus 2½ = 17½. L to M and H to J together equal half seat plus 2 = 20.

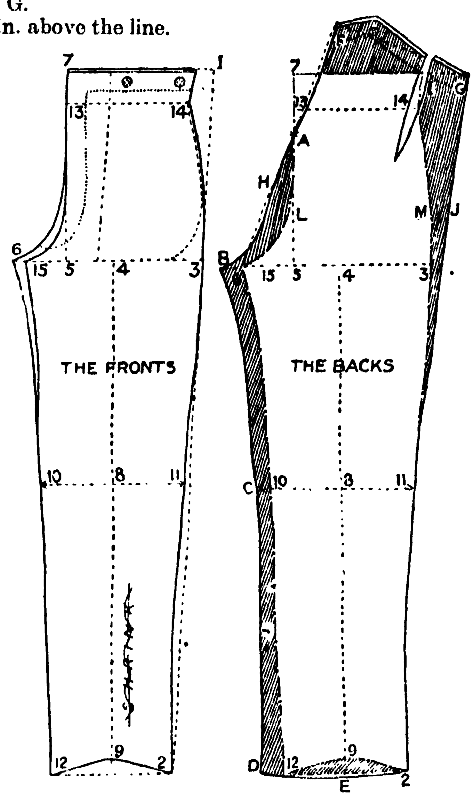
Square across from 1, then place square on seat seam and square across to G.

F. to K, 2 in.; K is 1½ in. above the line.

Take out fish 1 in. wide, about 3 in. from G and about 6 in. deep.

Cut from the cloth, leaving from 1 in. to 1½ in. inlay at the bottom for turn-up, about 1 in. up the side seams and 1 in. up the seat seam for inlays. Some also leave an inlay at the top of leg seam. Snip the side seams of top and under sides at knee on both leg and side seams to facilitate their going together fairly in the making up. Put sufficient cloth in to make pocket facings, fly, etc., and proceed with the trimmings.

Materials for Trimmings. ⅜ yd. pocketing; ¼ yd. silesia to match; ⅛ yd. linen to match; ⅛ yd. striped silesia for waistband lining; ⅛ yd. canvas; 7 large and 5 small buttons; 1 yd. of twist to match; a skein of silk; trouser binding, 6 in. over the waist measure; sundries according to details of order.



2. 3.

TROUSER DRAFTING

Stitches. In the making up of trousers, we have to consider the various stitches used.

Thread-Marking. Take a fairly large needle and thread it with a long thread of basting cotton, double. Take the part to be " thread-marked," see that it lies fair, and then put in long stitches exactly along the line wherever there is an inlay. Cut between the two stitches and pull the thread along so as to leave only sufficient cotton for the purpose as shown in **4**; now separate the top layer from the lower, and cut through the stitches, thus showing the exact quantity of inlay on either side.

Basting. The basting stitch is simply a long fore or running stitch, and is used to put the various parts together previous to the machine stitching. This is known as tacking by dressmakers, and is illustrated on page 125. The basting stitch shown there is a form of this stitch, which is used for keeping two or three layers of materials in place.

Backstitching. This is the most important stitch used in tailoring, as well as the strongest. The thread enters the cloth at 1, travels through to the other side and up at 2, it enters again at 3, and comes out at 4, enters at 5, and comes out at 6, enters again at 2, and so on, the full length of the seam [**5**].

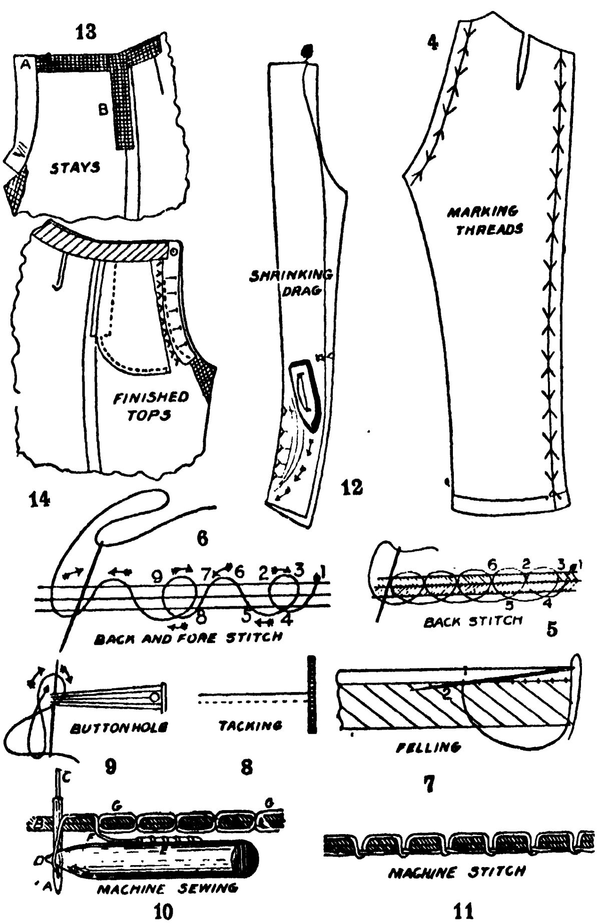
Back and Fore Stitching. This stitch is used when it is desired to get over the work speedily. It consists of one back stitch and one fore stitch, alternately; thus it enters at 1, comes out at 2, goes back to 3, comes out at 4, goes on to 5, comes out at 6, and then goes forward to 7, out at 8, through to 9, and then back to 7, and so on, as indicated by the arrows [**6**].

Felling. There are various styles of felling, one being that shown on page 125; the form generally used by tailors is that shown in **7**. The needle is inserted in the under material quite close to where it has come out on the upper material; it is then brought forward the length of one stitch and brought close to the edge of the upper material, thus enter cloth at 1 close up to the lining, come out of lining at 2 close up to the cloth. This is used for securing lining, etc., to the main part of the garment.

Tacking. Various forms of this stitch are used by tailors; we merely give the style mostly used for pockets. It is generally done with twist. First put in at least three stitches over and over, of sufficient length, say, ½ in. to ¾ in.; this goes through cloth and linen, and its object is to make a very secure ending to the pockets. The long stitches being put in, proceed to bring up the needle close to the end of the tack, then put it through on the other side of the twist, and so hold it down; repeat this as regularly as possible until the entire length of the tack has been covered with these over and over stitches [**8**].

Buttonhole Stitch. The buttonhole being cut of the correct length, first put in a bar thread either of gimp, four-cord thread, or double twist, as shown by the double line. Now start from the left-hand end of the top side, insert the

needle close up to the end, and then bring the twist up and cast it over the needle from left to right, and draw the needle up at such an angle as will raise the "purl" the desired amount. The stitches in a buttonhole should be regular both in depth and width, and the hand should always be drawn up at the same angle so as to retain regularity of "purl." The stitches at the eye may be a little closer together, and the "purl" brought a little higher than the other parts. The end of the hole is finished with three over-and-over stitches and three "purl" stitches just over these; they are then drawn together and pressed, the edges being *bitten* up to make a good finish [9].



4—14. DETAILS OF TROUSER-MAKING

Machine Sewing. Of the various kinds of stitches made by sewing machines, the lock stitch alone needs comment. The machine stitch is made by the twisting or interlocking of two threads, and great care is necessary in the adjustment of the tensions of the two threads to ensure getting the machine stitch at its best. It is illustrated in **10**. C is the needle, with eye near the end, carrying a thread A. B is the double thickness of cloth to be seamed, D is the nose of the shuttle with thread coming out of the top at E, F shows the last completed stitch, the tensions being arranged so as to cross exactly in the centre of the two layers, thus ensuring the most possible elasticity. In **11** we show how the stitch is formed when the lower tension is tight or the top much too loose, the result being that the least strain snaps the thread, and the stitches go. A good stitch appears the same on both sides.

Stretching and Shrinking. The peculiar formation of the wool fibre enables the tailor to stretch or shrink different parts of the cloth by the use of moisture and a hot iron. This is employed in various parts of garments, but in trousers it is principally used at the bottom of the top sides and the thighs of the under sides. The principle is the same wherever it is used. Fold the cloth over at the part to be shrunk, wet it, and then bring it round so that the cloth forms puckers. Then apply a sharp iron, and work it round as shown by the arrows on **12** until the form desired has been imparted. The under part shrinks most, and to get both sides alike it should be turned over and the operation repeated.

The Making. First mark up the inlays with marking threads, then shrink the bottoms—some tailors do this before they are seamed, others do it at a later stage. Put in the stays for the pocket in top side, and stitch the mouth about 6 in. deep. Put a piece of linen on the fork of top side [**13**]. Now baste the seams, keeping the balance marks together; seam them together either by hand or machine, but always seam five or six inches down from the top of leg by hand; press open the seams and put linen stays on for the pockets at B, at the back of the facings that have been sewn on at that part. Put canvas round the top, as at A, seam on the button-catch on the right side to within 2 in. of the fork, and put linen down the back of this to take the buttons.

Now make up the fly, and line the front at that part of the left top side with silesia. Work five buttonholes as marked in **14**. Baste up the fly, make up and put on the pockets, having tacked the top and bottom. The pocket is felled to the facings of the top side, and to the linen and facing of the under side. Stitch on the fly and continue the stitching round the tops. Bind the tops, press them, and sew on the buttons. Close the seat seam and tack the fly with some neatly "pricked" stitches. Press the seams, put on the waistband and crutch linings, and then turn up the bottoms, making the length of leg to measure. The trousers are now ready.

W. D. F. VINCENT

Recovering and Refining Gold and Silver. Sampling and Assaying. The Work of the Mint.

THE PRECIOUS METALS

In this chapter there is outlined the production of the precious metals in the conditions in which they are used in coinage and the industries, with their application therein. The methods of extracting the important precious metals, gold, silver, and platinum, are also dealt with in the course on MINING.

Gold. Gold has a yellow colour, its lustre is proverbial, and it exceeds all other metals in malleability and ductility. Its tenacity is moderately high, but is diminished by the presence of lead, tin, antimony, and some other metals, while copper and silver increases it. Its specific gravity is 19·32, and its melting point 1060° C. Its conductivity stands next to that of silver and copper. It is not acted upon by the atmosphere, by hydrochloric, sulphuric, or nitric acids, or by sulphur compounds. It is soluble in chlorine, aqua-regia, and potassium cyanide.

Gold is found in the metallic or native state, generally alloyed with other metals, and in combination with tellurium. Native gold usually contains silver, and sometimes copper, iron, bismuth, platinum, palladium, or rhodium.

The ores of gold differ conspicuously from those of all other metals in the extremely small proportion of the metal sought to the amount of valueless material, or "gangue," accompanying it. Practically all gold deposits now worked contain not more than from one part of gold in from 70,000 to 100,000 parts.

Silver. The properties that make silver so valuable are its pure white colour, its softness, sonorousness, extreme malleability, ductility, tenacity, and toughness. It exceeds all other metals in its conductivity for electricity. It melts at 960° C., and has a specific gravity of 10·53. It does not oxidise in air, although it mechanically absorbs oxygen when melted, and gives it out again on cooling. It readily unites with sulphur, forming a blue crystalline sulphide. With chlorine, bromine, and iodine it unites, forming important compounds. It is soluble in nitric and sulphuric acids.

Silver occurs, both free (mixed with gold, mercury, or copper) and in combinations which differ so considerably that the metallurgy of the metal is very complex. Silver is also a valuable constituent of galena, zinc-blende, most of the pyrites, and of some copper ores, though the percentage is very small (up to 1 per cent. compared with from 60 per cent. to 87 per cent. in the case of the ores).

Extraction Processes. Gold may be extracted from its ores either by simple washing (in the case of native gold) or by metallurgical processes, when it is amalgamated with mercury, or alloyed with lead, silver, or copper, or is brought into solution. The metal is obtained from mercury alloys by distillation; from lead or lead-silver alloys by cupellation; from silver or silver-copper alloys by solution in acid; and from weak cyanide or chloride solutions by precipitation with ferrous sulphate, charcoal, or zinc, or by electrolysis.

The Siemens-Halske electrolytic method is now largely employed. The double cyanide solution is electrolysed in iron tanks between lead cathodes and iron anodes, and the gold recovered from the cathodes by cupellation.

Silver is obtained from its ores by means of mercury (amalgamation processes), by means of lead (smelting processes), and by various wet methods (solution processes).

Amalgamation. Amalgamation, the combination of gold or silver with mercury, is the cheapest, simplest and most generally used method of extracting these metals. It is the basis of hydraulic gold mining, and of the stamp-battery process. In Mexico the old processes of crushing and amalgamating gold and silver ores in *arrastras* (revolving stamp-mills driven by mules) and heaps (*patio* process) are still carried on, but electricity is gradually displacing mules.

The ore is first converted into chloride by means of a copper salt and common salt, then decomposed by mercury, with which it unites to form an amalgam. The mercury is afterwards driven off by heat, leaving the silver pure. The processes are lengthy and wasteful of mercury, but they extract a greater precentage of metal than any other known process.

The amalgamation method is now conducted by means of stamp batteries and amalgamating iron pans. The ore is crushed by stamps, water being admitted. The ore mud is transferred to settling pits, and then carried to the amalgamating pans. The pans are of various types, and consist of an iron box about 4 ft. in diameter and 2 ft. high. A central cone supports a revolving shaft with arms, from which are suspended grinding mullers, which press the ore to a pulp. Mercury is then added, and the rotation continued until the silver is amalgamated. The amalgam is then removed, washed, dried, strained, and the mercury distilled off in retorts. In ores containing much base metal a preliminary roasting in a furnace is necessary, with the addition of common salt to form silver chloride. In this case the ore is dry crushed, and larger pans are used for amalgamating.

Lead Methods of Recovering Silver. Lead methods are based on the reducing action of lead on gold and silver, with the solution of these metals in metallic lead. As complex ores are treated in this way, the products are also complex.

The principal metals obtained are gold, silver, copper, and lead. The ore is first roasted in a reverberatory furnace to remove sulphur, arsenic, and other volatile substances, and then smelted in a blast furnace. The charge consists of roasted ores, pyritic ores, various residues, and slags. The products may be lead (containing gold and silver), regulus (containing lead, copper, iron, and sulphur) and slag. The last is either used again if it contain sufficient metal, or, if not, it is thrown away. The fume from the furnace is also condensed for the recovery of lead. The lead containing gold and silver is first submitted to the Pattison process for concentration of silver, and afterwards cupelled for the recovery of gold and silver. The regulus is roasted, and added to another charge in the blast furnace to remove its contained silver and gold. The second regulus may be treated for copper. The gold and silver are separated by the parting process subsequently described.

Wet methods of extracting silver are based on the principle of converting compounds of silver into a soluble form, and then precipitating the silver by means of a base metal or a compound. The three principal methods employed are Augustin's, Ziervogel's, and Von Patera's.

The Augustin Process. The Augustin process is used for argentiferous regulus and residues, which are first roasted in air to remove sulphur, then with common salt, to form chloride. The next stage consists of lixiviating the roasted ore in wooden vats with a strong, hot solution of common salt, which dissolves the silver chloride. The solution is run off and the silver precipitated by means of copper.

The Ziervogel Process. The Ziervogel process consists of roasting sulphur compounds containing silver at a moderate temperature to form silver sulphate, which is soluble in water. The roasted mass is removed, cooled and lixiviated with water, and the silver precipitated by copper. If sufficient sulphur be not present, then pyrites are added. If the temperature be too low, then the sulphate is only partially formed; if too high, the silver sulphate is decomposed again to metallic silver. The success of the process depends on the proper temperature of roasting.

The Von Patera Process. The Von Patera method is used for chloride ores, which are roasted with salt, and lixiviated with sodium thio-sulphate. The silver is precipitated by sodium sulphide, and the silver sulphide decomposed by heat. This method has received extended application by the use of double thio-sulphates, known as the *Russell* process. In the Von Patera process, any lead sulphate that is present dissolves in the thio-sulphate solution, and is precipitated, along with the silver, as sulphide.

In the Russell process the lead is precipitated by means of sodium carbonate. Moreover, it was found that by using a double thio-sulphate of sodium and copper, a more energetic decomposing and dissolving action on metallic silver, silver sulphide, and the combinations of silver with arsenic and antimony took place. Hence, if the roasted ore is first treated with sodium thio-sulphate to dissolve the silver chloride, and the residues subsequently treated with copper thio-sulphate solution, much more silver is extracted than by the older (Von Patera) method.

Recovering Gold. Gold quartz is very hard and compact, and contains the gold in veins. The ore is first crushed by rock breakers, and then reduced to a fine powder by the stamp battery, the mortar of which is lined with amalgamated copper plates for taking up the gold. The residual matter is often treated in amalgamating pans.

A stamp battery generally consists of five stamps working in one mortar, which is made of an iron casting about five feet long. The feed opening is on one side of the mortar, and on the other is a fine screen of wire cloth through which the discharge takes place. The drop of the stamp varies from 4 to 18 in., with about 100 blows per minute. In front of the screen are inclined tables covered with amalgamated plates to catch the gold which has not been collected on the plates inside the mortar. The material escaping these plates is concentrated by some kind of shaking machine which separates the lighter from the heavier particles which contain some gold. These concentrates are amalgamated in iron grinding pans. The gold amalgam is retorted to volatilise the mercury and retain the gold.

The Chlorine Process. The chlorine process of extracting gold consists of (1) roasting the ore to remove sulphur and base metals; (2) moistening with water and passing a current of chlorine through it in a wooden vat, having a perforated bottom, which acts as a filter, and through which the gold solution percolates; (3) running off the solution and precipitating the gold by iron sulphate or other suitable reagent. Ores and residues are usually concentrated before being submitted to the chlorination process. Compressed chlorine is also used and is very effective, but more expensive. The operation is conducted in revolving barrels lined with lead.

The cyanide process of extracting gold was introduced by McArthur and Forrest, in 1887. The ore is first crushed in rock breakers, then in rolls or stamp batteries, then placed in vats to which a 1 per cent. solution of potassium cyanide is added, which dissolves the free gold. The solution is then removed, and the gold precipitated by means of zinc.

Gold is extracted by smelting processes from rich copper regulus. The regulus is partially roasted, and then the oxide and sulphide react on each other, reducing the copper and gold, forming an alloy. The copper is deposited by the electrolytic method, when the gold is left, and is afterwards melted with lead and separated by cupellation.

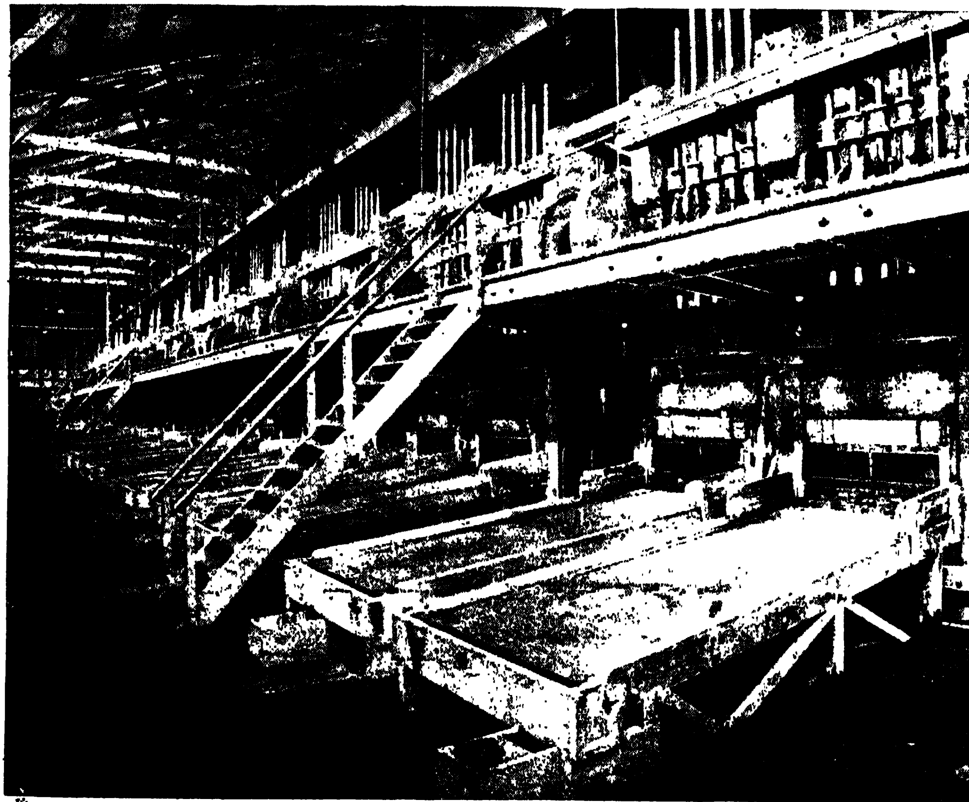
Purification and Filtration. In stamp-battery amalgamation the amalgam settles in the corners of the mortars, or on amalgamated copper plates on the inner sides of the mortar.

The pulp escaping from the mill is made to flow over amalgamated copper plates to catch any free gold or amalgam passing over. The amalgam is removed from the plates by means of blunt knives followed by scraping with pieces of hard rubber.

The amalgam removed from the outside plates in a battery is usually clean and stiff enough to be retorted without any further treatment. But gold amalgam obtained from the inside of the mortar, and from the treatment of concentrates, frequently contains sand, pyrites, and other impurities, from which it must be cleansed, while the gold amalgam produced in hydraulic operations, and all silver amalgams, contain excess of mercury.

Excess of mercury is separated from the amalgam by filtration through a conical canvas or chamois leather filter-bag [1], supported on an iron stand, and holding about 12 cwt. of amalgam. The weight of the amalgam is sufficient to force the greater portion of the mercury through the bag. If, as is sometimes done, air pressure is applied, more mercury is expressed, but it is richer in gold or silver. Hand-squeezing of the filter-bag by twisting it in water contained in a mercury pan is still considerably employed.

The solid amalgam removed from the filters may contain from 20 per cent. to 22 per cent. of silver, or about 40 per cent. of gold, in the case of single metal amalgams, and from 30 per cent.



Photo

A STAMP BATTERY IN A GOLD MINE ON THE RAND

to 45 per cent. of gold and silver, where, as is usual, both metals are present.

In small mills the cleansing is done by hand-grinding the amalgam in a mortar with water until it is reduced to a thin liquid, a scum being obtained, which is skimmed off and reground with more mercury. In large mills mechanical clean-up pans are used. The Knox and Berdan pans are the two commonly used pans. The Knox is similar to the silver amalgamating pan, and acts on the principle of agitating the dirty amalgam with water, so that the impurities form a scum on the surface. In the Berdan pan, the pan, inclined at an angle, itself revolves, and impurities are washed over the lower edge by a jet of water, grinding being effected by a freely moving ball.

Retorting. Gold and silver are recovered from the amalgam by distillation. Two kinds of retort are used for this purpose—the pot-shaped [2], much used in America, and the horizontal cylinder [3]. The pasty amalgam is kneaded into balls or cakes. In the horizontal retort the balls of amalgam are separated by iron divisions or by the ash of notepaper.

Adherence of gold or silver to the sides of the retort is prevented by a layer of chalk or whiting, or by the ash of sheets of paper. The mercury is condensed in the usual manner by water-cooled tubes. The metal obtained is spongy and porous

and varies from 500 to 950 fine in gold, the remainder being silver and the base metals. It is melted down with fluxes, cast into bars, and then becomes "bullion" ready to be refined. This is usually the termination of the mine works operations, and the bullion is sold to refiners for further treatment.

Preliminary Refining. Gold and silver alloy in all proportions so that practically all bullion contains both, and refining operations are conducted with a view to their ultimate separation, which is effected by "parting."

Base metals and other impurities are partly removed by a rough refining process at a preliminary melting of the bul ion, but the extent of it is limited by the fact that the molten oxides formed rapidly corrode the crucibles. The crucibles used are of clay or graphite. The crucible is first raised to a red heat, a spoonful or two of borax is thrown in as a flux, and the bullion is then fed in by means of a hand shoot. If the bullion is of high purity only a very little sodium carbonate or nitre is added and the resulting slag is poured off with the metal.

But if it be base, partial refinement is effected by adding more borax and nitre, and also bone ash to absorb the oxides formed. If much lead is present, sal ammoniac is added at intervals alternate with nitre. Antimony or arsenic are removed as iron salts by stirring with an iron bar, and using but little nitre.

One hundred years ago it was proved that when bismuth, lead, antimony, or arsenic are present in gold in proportions as small as $\frac{1}{1920}$ the gold is brittle and unfit for coinage. The further treatment thus sometimes necessary is called *toughening*, and is effected by converting the contaminants into their volatile chlorides, either by sprinkling ammonium and mercuric chlorides on the melt, or by forcing chlorine gas through it (Miller's process). The Mint chemist recommends the use of oxygen for toughening.

The charge is then rendered homogeneous by stirring with a red-hot annealed graphite bar. In the bottom of the ingot mould is placed a little non-volatile oil, which burns on the top of the gold and prevents tarnishing.

Electrolytic Refining. In electrolytic refining of copper and silver by the appropriate processes practically all the silver and gold, or the gold alone, are left in the anode slime, from which they are readily recovered. Gold, however, cannot be electrically separated from a cyanide solution containing silver, copper, etc., because these metals are co-deposited therefrom; but an electrolytic method devised by Wohlwill has been successfully used in Germany. The electrolyte is a hot acid solution of gold chloride, and a smooth deposit of gold, assaying over 99·9 per cent. pure, is obtained. All the foreign metals of the anode pass into solution, except those of the iridium group, which remain unattacked, and silver, which forms its chloride; platinum and palladium accumulate in the bath, being removed at long intervals by precipitation. The process is thus particularly appropriate to gold alloys of platinum.

Silver, over 99·9 per cent. pure, is electrolytically obtained by Moebius's process from cast crude anodes of doré silver in a half per cent. bath of silver nitrate made slightly acid. The cathode is an endless revolving band of thin rolled silver upon which the metal is deposited in a pulverent and non-coherent condition, and automatically removed by contact at one end with a moving belt. The gold is recovered from the anode slime.

Refining by Cupellation. As explained above, the rough refining operations included in the melting of the metal before casting are limited in extent, and bullion containing considerable quantities of contaminating metallic oxides must be treated to "cupellation," a process of great antiquity, by means of which pure gold or, more frequently, a pure alloy of silver and gold, is obtained. It is also the principal refining operation applied to the product of the lead-alloying gold or silver extraction process. Its principle consists in the fact that molten lead monoxide (litharge) dissolves any metallic oxide which may be in contact with it. The separation of the litharge solution of oxides, thus obtained, from the pure noble metals which do not oxidise is effected by taking advantage of the property of bone ash of absorbing molten litharge, including its solutes, while remaining impermeable to the unoxidised metals. In practice this is achieved by making a shallow vessel of compressed bone ash, called a "cupel," from well-burnt, sifted ashes of sheep or horse bones mixed with a small proportion of fern or pearl ashes, and moistened sufficiently to bind on pressure. An oval vessel [4] of from 4 ft. to 5 ft. long, and 2½ ft. to 3 ft. wide, with a depth of about 2¾ in., may be used in large operations, with walls of from 2 in. to 3 in. thick, one end being made 12 in. or 13 in. thick. Frequently the bed of a reverberatory furnace itself is used, a layer of bone ash, or, more frequently in large works, a mixture of crushed limestone and clay, being placed thereon. The cupel is placed in a reverberatory furnace, and, when red-hot, molten bullion and lead are ladled in. The cupel soon becomes saturated with the litharge oxide solution which flows to the side, and an air-blast is then turned on to force the litharge towards the thickened end of the cupel, across the surface of which a channel is cut. The litharge runs over into an iron pot, more molten lead or lead alloy being added as litharge is removed. In this way six or more tons of lead alloy may be refined in one cupel. Only traces of the precious metal are carried into the bone ash by the litharge.

Although gold is not accounted volatile, volatilisation losses in cupellation may amount to 0·5 per cent. They are diminished by the presence of silver, and increased by copper. The cupels used are re-powdered and gold and silver recovered.

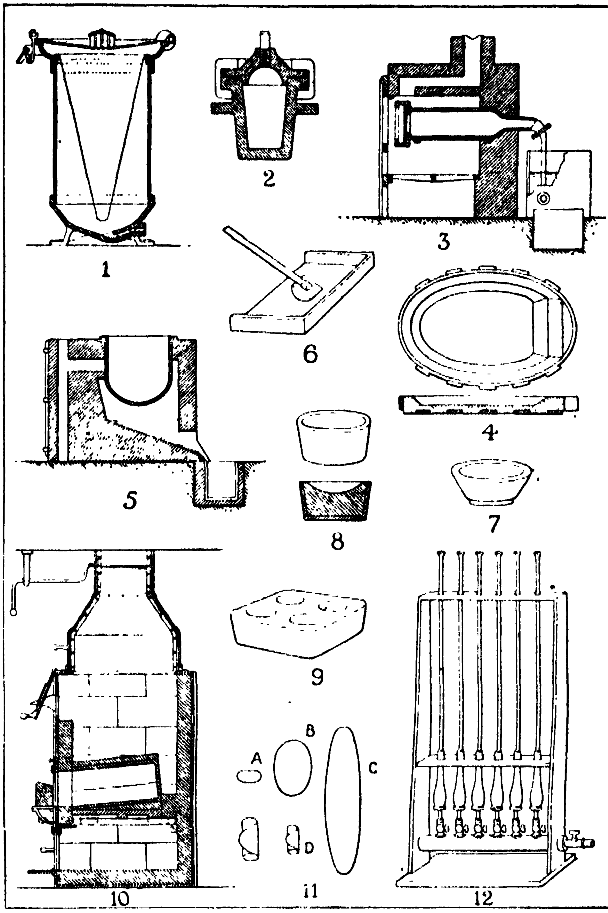
Parting. The final operation of separating the silver and gold is known as "parting." The old process of parting with nitric acid was known as "quartation" or "inquartation," because the alloy refined was made up to 3 parts of silver and 1 of gold. It is still the process used in assaying and is described in that connection: but it is not otherwise used on account of the cost of the acid.

Sulphuric acid is now generally employed in large refining operations. Copper and silver are converted into their sulphates by hot concentrated sulphuric acid, while gold is unattacked. In this process the gold (and copper, if any) present must not exceed one-fifth of the total alloy; 80 to 95 per cent. of silver being required, and these proportions are made up, if necessary, by adding silver before cupellation or melting.

The alloy is granulated and boiled with concentrated sulphuric acid in a platinum, white pig-iron [5], or clay-coated porcelain vessel. When action ceases, a little weaker acid is added and the alloy again boiled. The liquid containing sulphates is then decanted off, and the gold (which may again be treated with acid) washed, melted, and cast into ingots. The gold thus obtained is 997 to 998 fine.

The acid sulphates liquor is poured into a leaden vat containing water and copper turnings, and heated. Cupric sulphate is formed, and the precipitated silver is collected, repeatedly washed, and cast into ingots. The sale of the by-products (copper sulphate and acid) more than covers the cost of the copper used. At San Francisco green vitriol (ferrous sulphate) is used for reducing the silver sulphate. It is also reduced by means of sheet copper.

The process of parting gold and silver by converting the latter into its chloride, suggested by F. B. Miller and largely employed in the Australian mints, is referred to above. The bullion refined by this method contains originally from 3 per cent. to 12 per cent. of silver; after refining it is 994 fine. Australian gold is more or less brittle and the process is valuable for its toughening effects, as well as for its applicability to alloys containing but a small proportion of silver.



REFINING AND ASSAYING APPARATUS

1. Amalgam filtering bag **2.** American amalgam retort **3.** Amalgam retort with condenser **4.** Refinery cupel **5.** Iron parting vessel **6.** Bucking plate **7.** Scorifier **8.** Assayer's cupel **9.** Mint assay cupels. **10.** Mint assay furnace **11.** Preparation of gold-silver button for parting. **12.** Assay parting flasks

Platinum. Platinum is a lustrous, greyish-white, malleable, ductile metal, which is neither attacked by air nor acted upon by acids (except *aqua regia*). It therefore has claims to be included as a noble metal, and as its market value (about £8 15s. per oz.) is higher than that of gold, it is also a precious metal. At a red heat it may be welded, but cannot be melted by a temperature less than that of the oxyhydrogen flame. It is oxidised by fused caustic alkalies, and is also attacked at high temperature by cyanides. Platinum and iridium were not known in ancient times. Platinum is extensively used in high-class jewellery. Gold and other platinum alloys are used in mechanical dentistry.

Platinum ore contains what are known as the platinum metals—ruthenium, osmium, rhodium, iridium, palladium and platinum—in the metallic state. The most important sources are the western slopes of the Urals and the Altai Mountains. It is also found in alluvial deposits and sands, chiefly in Brazil, Borneo, Fraser River (B.C.), California, and Australia. It consists of from 60 per cent. to 80 per cent. of platinum. Osmiridium, a 30 per cent. to 40 per cent. osmium alloy, which is frequently found with it, is referred to below.

Platinum is separated from osmiridium by digestion with *aqua regia*, and from this solution it is precipitated by adding sal ammoniac. The precipitate is heated, treated with sal ammoniac to remove palladium and rhodium, and the resulting precipitate converted, by heating, into spongy platinum.

Osmiridium, frequently present in Californian and Canadian gold, is usually not detected until after parting, when it is seen in bar gold as specks or clots distributed through the metal. It is removed by re-fusing the gold, when it settles and forms what is known as a "bottom," which is cut off and repeatedly re-melted with silver. The bottoms are cut off each time, gold being replaced by the silver. It is finally separated by parting with *aqua regia*, when it is obtained as a black powder, which is sold for fountain-pen points at from 8s. to 20s. per oz.

Assaying. The assay of the ores and bullion of gold is conducted in the dry way, but silver bullion is also assayed in the wet way. The same dry methods apply to gold and to silver ores, since the metals are very rarely found separate. The principle of the assay is very simple, but its details vary greatly with the nature of the ores.

In the wet, or volumetric, process for silver assay the alloy is dissolved in nitric acid, and the silver estimated by the amount of a standard solution of common salt required completely to precipitate the silver nitrate as chloride.

Assaying weights are a law unto themselves. No scientific work is now done with the cumbrous English system of weights, but the custom still survives of expressing assay results in troy ounces per long English ton of 2,240 lb. avoirdupois, or short American ton of 2,000 lb. The metric system is rendered available by using a special weight called an "assay-ton" (A.T.) which bears to the ton the same proportion as the milligramme does to the ounce troy, so that each milligramme found in a sample represents 1 oz. per ton of ore. For the long ton the A.T. equals 32,666 milligrammes.

Sampling. The value of the sample of ore, or other material taken for assay, must approach as nearly as possible the true average value of the whole of the mine or material reported on. However great the accuracy of the assay, the result may be entirely negatived by careless or false sampling.

Sampling gold ores is a particularly delicate matter. In a finely-powdered ore containing 5 dwt. to the ton (a frequent proportion) a 1 milligramme particle of gold, about equal to the size of a full-stop, would possibly be accompanied by 160,000 similar sized particles of other substances. To get a correct sample of reasonable size of such a powder as this it is necessary to powder the ore more finely.

A true average sample is obtained in practice by automatic means. Sampling machines act either on the principle of continuously diverting a portion of a falling stream of broken ore or by diverting the entire ore stream at regular intervals.

By this means a ton sample of ore, broken to the size of coffee-beans, will be reduced to about 20 lb., and is then ready for further treatment in the assayer's office. There it is reduced in an iron mortar and a bucking-plate [6] till it will pass through a sieve with 80 meshes to the inch. Then it is well mixed and spread in a heap, which is carefully divided into quarters, one quarter being taken and again quartered until a sample of the required weight is obtained. If "metallics"—that is, pieces of gold of appreciable size—occur in the sample, they must be concentrated in a small portion by sifting, and assayed separately.

Bullion is sampled by dipping from the melt, by drilling holes in ingots and taking the turnings, or by removing pieces from opposite ends of the ingots.

Crucible and Scorification Assays. Fusion of the ore sample in the clay crucible with from once to twice its weight of a flux containing, typically, litharge, sodium bicarbonate, borax, and flour is adopted for ores of low gold value and for certain silver ores. The mixture is heated in a muffle or crucible-furnace until the charge is perfectly liquid, when it is poured into a mould. The slag containing the impurities is removed from the resulting lead button in which the silver and gold are concentrated, and the button is cupelled.

Scorification—that is, the conversion of silica and other gangue constituents into scoria—differs from cupellation only in the fact that the litharge produced is not absorbed by the vessel in which the operation is conducted, but forms a glassy slag. The scorifier [7] is a shallow dish of burned clay in which the ore sample, mixed with granulated lead and a little borax, is heated in a closed muffle furnace. When the lead is oxidised it dissolves the non-metallic and oxidisable constituents, flowing to the side of the scorifier as a slag, while the gold and silver alloy with a part of the lead which remains in metallic state. A glassy, brittle slag is obtained, which separates cleanly from the lead button, leaving it ready for cupellation.

Bullion Assay. If the composition of the alloy is entirely unknown, a preliminary assay is made to ascertain approximately the proportion of gold and silver, since (1) upon them depends the amount of lead used in cupellation, and (2) the final "parting" demands a definite ratio of silver with gold. Experienced assayers determine these quantities from the colour of a cupelled sample bead or of a streak upon the touchstone (Lydian stone, a silicified wood). The sample taken is flattened, adjusted to an exact weight by filing, and then weighed with great accuracy on a very delicate assay balance. It is then wrapped in the required amount of lead foil (eight times for standard gold), with silver equal to twice the weight of gold present. This proportion was first used in 1627, and was reverted to in 1905 by the Royal Mint after 50 years' disuse.

Cupellation and Parting. The principles of cupellation have already been explained. The cupel [8] used in ore assays is about 1 in. in diameter by ¾ in. high. At the Mint a special form [9] is used, so that 72 assays may be cupelled at one time. Eighteen square bone-ash blocks—for example, with four cupel hollows—are used, fitting into a special muffle furnace [10] with a floor space of 6 in. by 12 in.

At the completion of cupellation, when the alloy bead is uncovered a sudden brightening of the bead is noticed at the moment of solidification, called "flashing" (due to the release of the latent heat of fusing). This is useful not only as a help in finding a minute bead, but also because it affords a means of ascertaining whether iridium, osmium, rhodium, or ruthenium are present, since these troublesome metals entirely prevent the phenomenon. In the case of pure silver this is the last of the operations, and the button can be directly weighed.

At the Mint the button [11A] of silver and gold is flattened by hammering [11B], annealed, and passed through laminating rolls until it is the thickness of a visiting card [11C]. It is again annealed, and rolled into a spiral [11D] called a "cornet." These are matters of some skill, for small particles may easily be lost by cracks or roughness of the cornets. The cornets are first boiled with pure strong nitric acid [S.G. 1·2] in glass parting vessels [12]. At the Mint there are used platinum trays, on each of which 144 platinum cups containing cornets are placed, the whole being lowered into a platinum boiling vessel containing the acid at 90° C. The cornets are next washed with distilled water, and again boiled with stronger acid, repeatedly washed, dried, annealed, and carefully weighed.

Check assays are always made on pure gold to supply the correction necessary for the losses by volatilisation, cupellation, and acid solution. The gold finally obtained contains from 0·05 to 0·1 per cent. of silver. Mint weighings are now reported correct within 0·05 in 1,000.

Coinage. At an early stage in the history of civilisation it became necessary to have a definite medium of exchange. Metals, from their durability and portability, were very early in use, and gold and silver came naturally to be chosen from their intrinsic value. Reasons for the choice of gold, which partly apply to silver, are that it is too widespread to be liable to "cornering," as precious stones might be; that it is unalterable by time or ordinary chemical agents; that, wherever found, it is the same substance (unlike stones, which have faults not easily detected); that its value is the same whatever the size of particular pieces (the carat of diamond increases in value with the size of the stone); and, finally, though soft, it is readily made hard-wearing. Primitive payments were by weight, and this custom survives in our "pound," which was first a pound avoirdupois of sterling silver; while the penny was the weight in copper which we call a pennyweight.

Coinage has always been a regal privilege and mints date from the Anglo-Saxon period. In former times coining was carried out by contract with the Master of the Mint, but the head of the department on Tower Hill is now the Chancellor of the Exchequer, a deputy master being the permanent official.

Branch mints are established at Sydney, Melbourne, Perth, Calcutta, Bombay, and Ottawa, to supply their respective countries. Great Britain and the rest of the Colonies are supplied from the English Mint. The coins now struck are:

GOLD: £5, £2, £1, 10s.

SILVER: 5s., 2s. 6d., 2s., 1s., 6d., 3d.: and the Maundy money, 4d., 2d., 1d.

BRONZE: 1d., $\frac{1}{2}$d., $\frac{1}{4}$d.

The gold coins are $\frac{11}{12}$ pure gold and $\frac{1}{12}$ alloy by statute, and have been so uninterruptedly since the reign of Charles II. James I. debased the gold coinage to $\frac{8}{12}$ pure gold for revenue purposes. The silver is $\frac{37}{40}$ fine and $\frac{3}{40}$ alloy. The bronze is a mixed metal of copper, tin, and zinc.

"Trial" and "Remedy." When coins were made by contract it was necessary to ascertain periodically that the contract conditions were kept. This was called the "trial of the pyx," and it is still maintained with but little change. Finished coins are delivered in "journey weights," the supposed daily manufacture when coining was a hand process —15 lb. troy of gold (701 sovereigns), and 60 lb. troy of silver. From each of these deliveries one coin is taken and deposited in the "pyx," or chest, from which the annual trial derives its name. It is conducted in the presence of the King's Remembrancer by a jury of freemen of the Goldsmiths' Company, the coins being assayed against pieces cut from standard trial plates.

Variation in weight and constitution of coins from the standard fixed by law is permitted on account of the impossibility at present of ensuring an exact admixture of metals. It is called the "remedy," and is permitted to the extent of 2 and 1·6 parts per 1,000 for gold, and 4 and 4·17 for silver for fineness and weight respectively. Since a variation of $\frac{1}{10}$ of 1 part per 1,000 in the case of gold means a gain or loss of about £100 in a million sterling—its importance will be realised. In gold coins, however, a greater deficit, or excess, of from 0·3 to 0·4 per 1,000 is rarely met with. The legal standard is 916·6 parts per 1,000. The limit of weight variation for bronze coins is 20 parts per 1,000.

Light Coins. In the 1903 report of the Deputy Master of the Mint, Dr. Rose, the Mint chemist, stated that the average circulation life of the sovereign is 27 years, and of the half-sovereign 17 years. The coin has then lost by wear so much weight and fineness that it is legally uncurrent. Since the nominal and real values of gold coins are the same, this represents a considerable loss to the holders. In 1873 it was estimated that the loss on light coins in circulation from deficiency in gold amounted to about £650,000. The withdrawal of light gold coinage has been effected at intervals by raising the ordinary Mint purchasing price for light gold from £3 17s. 6½d., to the full statute Mint value of £3 17s. 10½d. per oz. Since the passing of the 1891 Coinage Act nearly £50,000,000 of light gold coins have been withdrawn by exchange at face value. In the case of silver these losses are covered by "seignorage," the difference between the real and nominal values of the coins. The yearly silver loss average for the decade 1896-1905, was over £35,000.

Coining Operations. In the early days of hand coining, cast bars of metal were hammered down to the required thickness, and the coins were cut therefrom with shears, the device being impressed by means of a hammer blow on a die. Now, however, the greatest care is taken, not only in the production of pure and accurate discs of the metals, but in the fineness of the alloy of base and precious metals used.

The Mint assay, melting and toughening operations for gold and silver have been described. The first operation now to be considered is the rolling of the cast bars into strips or "fillets." The manufacturing details for gold, silver and bronze coins are not materially different, and the sovereign will be taken as the type. The bar of gold, $\frac{1}{8}$ in. thick, is reduced by successive rollings (with frequent annealings to counteract the hardening effect) to the thickness of a sovereign. The accuracy of the thickness is tested by means of a gauge plate consisting of two steel bars set at a small angle graduated to $\frac{1}{1000}$ of an inch. For half-sovereigns a variation of $\frac{1}{1000}$ of an inch would more than account for the "remedy" allowed. The fillets are next tested by a "tryer," who cuts from them trial blanks, and by weighing on a delicate balance, classifies the fillets according to their weights.

Blanks for coins are punched in double rows from the fillets by cutting machines acting on the principle of the ordinary paper-punch. Bronze coins are cut five at a stroke. Slightly larger cutters are used for those fillets which have been classified as light, and vice versâ. The cut fillets, now known as *s issel*, equal from 25 to 30 per cent. of the original metal and are re-melted. So far it has not been found practicable to cut blanks from rods of metal, though such a method would represent a considerable economy.

In some mints the blank is adjusted to the required weight, but in London the finished coin alone is weighed, and the blanks are next thickened at the edge by rolling for the protection of the impression on the coin.

Coining and Automatic Weighing. The actual coining operation consists of placing the blank between two engraved dies in a press, the upper die being brought down upon it with considerable force. A collar surrounds the dies during the stamping to keep the blank in position, and, by means of cutting edges inside, to produce the milled edge. The coin is then driven down a delivery shoot by the succeeding blank. Ninety coins a minute are produced.

A COINING PRESS

The concluding operation is the automatic weighing of each coin by a set of wonderful machines, which infallibly distinguish between "light," "heavy," and "good" coins. The coins are fed in through a hopper, and received singly on the plate of a balance beam, one arm of which is weighted according to the coin tested. Rods raised by cams then release both ends of the beam, and, if the coin is "light," the plate-end of the beam rises; if it is "heavy," the weighted end rises: if "good," the beam remains practically horizontal. These movements of the beam govern the action of levers that determine into which of three orifices a delivery shoot, free to move by being hung on pivots, shall deliver the tested coin. The mouth of the shoot is directly in front of the balance-plate, the coin being driven into it by the coin next behind it.

The Invoice Guard Book. Filing Invoices. Trading Account. Goods Account. Gross Profit. Quantitative Method.

STOCK-IN-TRADE

We now come to a matter upon which the ultimate result of the trader's operations largely depends, namely, the taking of stock. But before proceeding to deal in detail with stocktaking, it is necessary to consider the method of keeping the records of the goods bought during the course of the trader's operations. In many businesses the invoices received from manufacturers are pasted into guard books in alphabetical order at weekly or other intervals, and from thence are entered into the invoice journal. On each invoice is noted in red ink or blue pencil—black ink does not show up well—the folio of the invoice journal on which it is entered, and in the journal is noted either the page of the guard book where the invoice itself is to be found or the serial number given to the invoice when it is in course of being passed for filing and entry.

The Guard Book. The using of a guard book without an invoice journal is not necessarily incompatible with the principles of double entry. In some wholesale houses the guard book is elevated to the dignity of a journal. On every page a money column is provided, into which the invoice amounts are extended, each amount being exactly opposite the total of the invoice to which it relates. The various invoices are posted separately from the guard book to the ledger, and the double entry is completed by posting the total of the money column to purchases account in the ledger.

By reserving a separate guard book for each department of a business a second and closer analysis of the transactions represented by the invoices is effected. In lieu of one grand total for purchases during a given period, we obtain as many guard book totals as there are departments; and the information will be of service when inquiry is made as to which departments are responsible for profits and which for losses, and the extent to which the different departments have contributed thereto.

Where but one invoice journal or guard book is kept for all departments, the analysis in the first instance merely resolves the invoice transactions into their debit and credit elements, there being one debit to purchases account (or goods account), as against a number of credits to the sellers of the goods.

Analysis Columns in the Invoice Journal. To distribute purchases over the various departments of a business, so that each department shall be charged with the goods it receives into stock, the original analysis must be supplemented by a further dissection, for which purpose analysis columns, similar to those in the analysis petty-cash book, are sometimes inserted in the invoice journal, each column being headed with the name or number of a department. In other instances, dissection sheets are resorted to. These are explained in due course.

It is doubtful whether, in view of the modern tendency to discard bound books in favour of loose-leaf books, card systems, and the like, the guard book will long survive the attacks made upon it. It has, however, justified its title by guarding the documents entrusted to its keeping, and, while capable of improvement in some respects, it excels in others.

Trading Account. Students may find it useful to refer to our previous remarks upon the treatment of invoices [see page 537], and afterwards to consider the following transactions of Messrs. Bevan and Kirk, namely, (*c*) to (*g*) inclusive, (*t*) and (*u*). It will be observed that they all relate to goods, some to purchases—(*c*) and (*t*)—some to sales—(*d*), (*e*), (*f*), (*g*)—and one to returns (*u*). Formerly, bookkeepers recognised no other classification for such transactions than that of "goods" or "merchandise," but the normal development of the analytic method has changed all that, and the primitive goods account is now broken up into several sub-accounts, which are periodically united under the title of trading account.

The Goods Account. The limitations of the method under which only one account was kept for goods will now be explained, and this will enable us to understand why the goods account has been altogether discarded by the modern accountant.

Mr. Andrew Crawford, of Liverpool, is the patentee of a portable heating and cooking apparatus, which he desires to introduce to the public under the trade name of the "Triumph" oil-stove. He decides not to risk his capital in building a factory and in laying down a suitable plant for making stoves of this description until evidence is forthcoming that the article has obtained a firm hold upon the public favour. No surer testimony to the existence of a genuine demand for an article can be found than that supplied by the steady increase in the sales of that article, season by season and year by year; and this is the evidence Mr. Crawford requires before embarking upon a course of action which would necessitate a large outlay of capital.

But if he will not make the stoves himself he must procure someone to make them for him. He therefore enters into negotiations with the Birmingham firm of Jones, Price & Co., hardware manufacturers, who undertake to supply his wants upon mutually satisfactory terms. The contract between the parties provides, among other things, that the price per stove, delivered at the patentee's warehouse in North John Street, Liverpool, shall be 8s. 6d. for size

A, and 11s. 4d. for size B, and that statements of account shall be rendered monthly, subject to 3¾ per cent. cash discount if paid within ten days from the date thereof.

Gross and Net Profits. So far, then, as goods coming in are concerned, Mr. Crawford is in the position of a wholesaler, but he has now to make up his mind whether he will attempt to reach the public direct or through the retailer. If he decides in favour of the latter and perhaps the wiser alternative, he will have to be content with a somewhat smaller rate of gross profit, because the retailer also is entitled to a profit, and usually obtains a higher percentage of profit than the wholesaler. If "Triumph" stoves were offered to the public at exorbitant prices, there would be an abatement, or possibly a total cessation, in the demand for them. Generally speaking, a small turnover with a high rate of gross profit is not so profitable a policy as a larger turnover with a lower rate of profit.

During the first year of his contract Mr. Crawford took delivery of 5732 A "Triumphs" at 8s. 6d., and 1476 B "Triumphs" at 11s. 4d. His credit sales throughout the same period were 5432 A stoves at 10s., 1419 B stoves at 13s. 4d.; 217 A stoves and 140 B stoves were, however, returned by customers for various reasons, and 79 stoves (28 A and 51 B) were sent back to the factory as being defective. There were no cash sales. With these facts before us we can exhibit the goods account in an abbreviated form, but it should be borne in mind that the account here given is not a copy but a summary of the account in Mr. Crawford's ledger.

Dr	Goods a/c (No 2)					Contra				Cr
1902 Dec 31	To Sundries (purch.)		3272	10		1902 Dec 31	By Sundries (sales)		3662	.	.
	" D° (returns inwards)		201	16	8		" D° (returns outwards)		40	16	.
	" Balance being Gross Profit tfd to Profit & Loss a/c		519		6		" Stock on hand (at cost)	c/d	290	11	2
			£3993	7	2				£3993	7	2
1903 Jan 1	To Stock	b/d	290	11	2						

The goods account is here shown in condensed form, but Mr. Crawford has adopted the detailed form which, at much greater length, supplies less real information. For every purchase, a journal entry is made debiting goods account and crediting Jones, Price & Co., and for every sale the customer is debited and goods account credited. Conversely, for returns to factory (returns outward), J. P. & Co.'s account is debited and goods account credited; for returns from a customer (returns inwards), goods account is debited and the customer's account credited. This is double entry with a vengeance! The number of items on the credit side of goods account may be gauged from the fact that in the first year of trading 249 accounts have been opened with retail ironmongers and others. Furthermore, a great many customers have sent "repeat orders," so that there are probably not less than six or seven hundred postings to goods account on the credit side alone. The debit side is briefer, as it relates chiefly to purchases from Jones, Price & Co., who despatch and invoice goods to Crawford, as per contract.

In a goods account built up item by item, not only are time and space squandered as the direct result of the method employed, but the account itself is perplexing, because it fails to discriminate between purchases and returns inwards on the one side, and between sales and returns outwards on the other. Omitting dates and journal folios, the goods account in Mr. Crawford's ledger would be set out as in the facsimile example shown on the next page.

Comparing this with the goods account, marked No. 2, we observe that, despite variations in structure, the two accounts agree as to the amount of profit balance, and as to the amount of stock in hand.

But the goods account has not fulfilled its office by merely disclosing the value of the stock in hand and the amount of gross profit earned; we wish also to know the *rate* of gross profit, the number and selling value of stoves sold in each month, the number returned, the total sales and purchases for the year, the ratio of returns to sales, and other useful facts about the business which are capable of being elucidated by means of the figures contained in the goods account. It thus appears that the *form* of the goods account is a matter of importance, because to be of service the information stored up in that account should be always accessible. It is a step in the right direction when specialised books of original entry are substituted for the journal, the monthly totals only of purchases and returns inwards, sales and returns outwards, being passed through the journal and posted to the goods account.

Accounts and Nominal Accounts. The most troublesome item in the goods account is that relating to stock. The reason exists

in the dual nature of the account itself. In the first place it belongs to the class of *real* accounts, which also embraces cash, bills payable, bills receivable, fixtures and fittings, and every species of property employed in or associated with an undertaking. But upon reflection we must admit that the goods account also belongs, in part at least, to the class of *nominal* or temporary accounts. Such accounts exist in name only; they are, in fact, sub-accounts, which for the sake of convenience are kept separate until merged by transfer in some account of superior degree. To this class belong the sub-accounts which jointly constitute the profit and loss account, as rent, rates, and taxes, salaries and wages, trade expenses, discounts, and sub-accounts of gains, losses, and expenses.

The goods account is related to this group through the sales. Every profitable sale is effected at a price which represents cost *plus* profit. The theory is that these accumulated profits are periodically transferred to profit and loss account, after having ascertained the value of the stock of goods on hand.

Stock in Hand. The value of the stock is ascertained by actual survey of the unsold goods, in the same way as the amount of cash on hand is found by counting the cash in the till. But while there should be an exact correspondence between the amount of cash in the till and the cash balance disclosed by the office cash account, there is ordinarily no such correspondence between the amount of goods on hand and the balance of goods account in the ledger. Theoretically, there is no reason why, after allowing for profit or loss on goods sold, and perhaps for reduced value of goods unsold, the balance shown on the goods account should not coincide with the value of the stock on hand as ascertained by survey—that is, stocktaking. We may illustrate this by an example. At the end of the first year's trading, Mr. Andrew Crawford learned as the result of stocktaking that he had on hand 489 size A and 146 size B "Triumph" stoves. These he valued at cost, and on this basis the stock was worth £290 11s. 2d., consisting of:

		£	s.	d.
489 A stoves @ 8s. 6d.	=	207	16	6
146 B stoves @ 11s. 4d.	=	82	14	8
Total		£290	11	2

The total agrees with the balance brought down on goods account No. 1 and on goods account No. 2, after the accumulated profits on sales have been transferred to P. and L. account. But those accounts are not sufficient in themselves to explain the coincidence. Attention is therefore directed to goods account No. 3, wherein the facts already dealt with in the two preceding accounts are treated quantitatively.

Dr.	Goods a/c (No 1)						Contra				Cr.
	To J. P. & Co		113	6	8		By Clements & Son		5	13	4
	" Hugh Bros.		2	6	8		" Thos Ballard		5		
	" J P & Co		113	6	8		" J P & Co		2	5	4
	" &c						" Hugh Bros		2	6	8
	" &c						" E W Langford		5	10	
	" &c						" Edw Wilson & Sons Ld		5	16	8
	" Balance, being Gross Profit transferred to P & L a/c		519	.	6		" Alfred Gill		1	.	.
							" &c				
							" &c				
							" Stock on hand (at cost)	c/d	290	11	2
		£	3993	7	2			£	3993	7	2
1903 Jan 1	To Stock	b/d	290	11	2						

By a slight rearrangement of the figures we are able to confirm the stocktaking quantities in the following way:

A.			B.
5732	No. of stoves purchased	1476	
28	Less returned to factory	51	
5704	Net purchases		1425
5432	No. of stoves sold	1419	
217	Less returned by customers	140	
5215	Net sales		1279
489	No. of stoves in stock, 31 Dec., 1902		146

Gross Profit. The selling prices of A and B stoves are 10s. and 13s. 4d., as compared with cost prices 8s. 6d. and 11s. 4d. respectively. Hence arises the gross profit of £519 0s. 6d. It follows that if cost and selling prices were identical the item "gross profit" would disappear from the goods account altogether, although the balance representing stock on hand brought down would remain unaltered.

Stocktaking proceeds quite independently of the goods account in the ledger. Nevertheless, the results of stocktaking must be known and incorporated in the goods account ere we can

decide the question as to whether a trading profit has been made.

Therefore the first step towards closing the goods account is to take stock. The second step is to credit by the value of the stock on hand the account about to be closed, at the same time opening a new account, and debiting it with the value of the stock transferred thereto. If the two sides of the old account then agree, we are forced to the conclusion that no profit has been made. If, as in the three accounts already given, the total of the credits exceeds the total of the debits, the difference or margin is gross profit. To dispose of this difference a transfer entry should be put through the journal and posted, debiting goods account and crediting profit and loss account [see rule of transfers, page 801].

In a goods account constructed on the lines of example No. 3 before us, we are able to utilise the recorded quantities and prices in verifying the accuracy of the gross profit as stated. We have seen that profits are derived solely from the sales, but that they are liable to diminution by the amount of any shrinkage in value of the unsold goods. In the present case there is no shrinkage, and the calculation to be performed becomes a simple matter. Allowing for returns from customers, 5215 A stoves were sold at 10s. each, being an advance over cost of 1s. 6d. per stove; therefore, the total profit on A stoves must be 1s. 6d. × 5215 = £391 2s. 6d. Again, 1279 B stoves were sold at 13s. 4d. each, or an advance over cost of 2s. per stove. The total profit on B stoves is, therefore, 2s. × 1279 = £127 18s. 0d. If this amount be added to the profit of £391 2s. 6d. on A stoves, we shall obtain a combined profit of £519 0s. 6d., as shown.

Dr — Goods a/c (No 3)

Date	Particulars	Fo.	£	s.	d.	£	s.	d.
1902 Dec 31	To Purchases							
	5732 "Triumph" A @ 8/6		2436	2				
	1476 do B @ 11/4		836	8				
						3272	10	
	To Rets from customers							
	217 A stoves @ 10/-		108	10	·			
	140 B do. @ 13/4		93	6	8			
						201	16	8
					·	3474	6	8
	To Gross Profit transfd to P & L a/c					519		6
						£3993	7	2
1903 Jan 1	To Stock	Fd				290	11	2
	489 A @ 8/6		207	16	6			
	146 B @ 11/4		82	14	8			
		£	290	11	2			

Contra — Cr

Date	Particulars	Fo.	£	s.	d.	£	s.	d.
1902 Dec 31	By Sales							
	5432 A @ 10/-		2716					
	1419 B @ 13/4		946					
						3662	·	·
	By Rets to factory							
	28 A @ 8/6		11	18	·			
	51 B @ 11/4		28	18	·			
						40	16	·
	By Stock (at cost)							
	489 A @ 8/6		207	16	6			
	146 B @ 11/4		82	14	8			
						290	11	2
						£3993	7	2

The Quantitative Method. Quantitative accounts of raw material, labour, finished products, and expenses of production are essential to every genuine system of cost accounts. Prime costing, as it is termed, is a latter-day development of accountancy, but more especially of the analytic method to which reference has been made. It is resorted to chiefly by the contractor and the manufacturer; by the contractor because estimates for work proposed to be undertaken should be founded upon data supplied by the prime cost accounts of executed contracts; by the manufacturer because thereby an efficient control over every department of manufacturing can be maintained.

Outside these two classes of business men, the quantitative method of account-keeping meets with small favour, and the reason is not far to seek. It is a good business maxim that the result aimed at should be commensurate with the effort put forth, and it is generally felt that the labour of keeping continuous and classified records of the quantities of stock bought and sold from day to day is too high a price to pay for the consequent benefit of being able to check the quantities of stock on hand as ascertained by actual survey with the balances appearing in the stock register.

Testing Stocktaking Results. Accordingly, business men have adopted a shorter method of testing the results of stocktaking which, although not absolute, answers all practical purposes. The method referred to consists in ascertaining whether the *rate* of gross profit earned is a proper one, having regard to all the circumstances. If the rate is normal, or varies but slightly from the normal, and the

prices, extensions, and summations of the stock book have been carefully verified, then the amount of stock on hand is assumed to be correctly stated; but if the rate is abnormal, an investigation of the goods account, including the item of stock on hand at the end of the period, will have to be made.

For instance, in goods account No. 2, quantities are not registered, but values only. Taking the net sales as £3460 3s. 4d. (£3662 - £201 16s. 8d.), the gross profit as £519 0s. 6d., and applying the rule for percentages, the profit works out at a rate of 15 per cent. on the sales (£519·025 × 100 ÷ £3460·16 = 15). Mr. Crawford is satisfied from this showing that the value of the stock is correctly stated, because his selling prices were calculated on a basis of 15 per cent. "on returns."

Thus, if 1s. 6d., which is 15 per cent. on 10s., be deducted from the selling price of A stoves, we shall arrive at the cost price, 8s. 6d.; so also, if 2s., or 15 per cent. on 13s. 4d., be deducted from the selling price of B stoves, the cost price, 11s. 4d., will stand revealed.

In a great many businesses, the stock comprises a variety of articles of trade, and the prices are legion. Here it would be folly attempting to prove the value of the stock by making calculations based upon the difference between cost and selling prices. The simplest plan is to adopt an *ideal* rate of gross profit for each business coming under this category, and to treat any marked deviation therefrom in the *actual* rate as a warning not to pass the item of stock in the goods a/c without further inquiry.

Determining the Ideal Rate of Profit. To determine the ideal profit rate which should obtain in a given case, it is advisable to fall back upon the experience of former years, or of other people engaged in the same trade. While it is true of trade generally that different rates of gross profit prevail where trades are dissimilar, it is, with certain reservations, no less true that in any particular trade there exists a recognised standard of gross profit to which the majority of the traders endeavour to conform. Industrial competition—that great leveller of prices—is mainly responsible for this tendency of gross profit rates to become uniform; but we merely note the fact, and pass on to illustrate the mode of applying the ideal or standard rate of gross profit in the detection of error.

Suppose that the goods account in Mr. Crawford's ledger had been kept in abstract form as shown in goods account No. 2, but that while the figures for purchases, sales, and returns were the same as given in our example, the amount of "stock on hand (at cost)" differed, being recorded as £248 1s. 2d. instead of £290 11s. 2d. We should expect to find this reduction in the ledger value of the stock reflected in the decrease of gross profit shown, and this is precisely what happens [see the facsimile account below].

Taking the *net* sales as £3460 3s. 4d. and the gross profit at £476 10s. 6d., Mr. Crawford would have discovered that the rate of profit worked out at slightly under 13·8 per cent. This result being clearly inconsistent with the fact of a 15 per cent. margin of profit between cost and selling prices, he would feel convinced that something was wrong. In the case we are supposing, a careful recount of the stoves in stock revealed the fact that a mistake had been made in counting 389 A stoves instead of 489. The error produced a depression of £42 10s. 0d.—representing the cost of 100 A stoves at 8s. 6d. each—in the *book value* of the stock. When the necessary adjustment had been made, the amount of stock would appear as £290 11s. 2d., the gross profit would be correspondingly increased to £519 0s. 6d., and the rate of profit would work out at 15 per cent. as required.

Dr. Goods a/c (No. 2a) — Contra Cr.

			£	s.	d.				£	s.	d.
1902 Dec 31	To Sundries (purch.)		3272	10		1902 Dec 31	By Sundries (sales)		3662		
"	Do. (returns inwards)		201	16	8	"	Do. (returns outwards)		40	16	
"	Balance, being Gross Profit tfd. to Profit & Loss a/c		476	10	6	"	Stock on hand (at cost)	c/d	248	1	2
			£3950	17	2				£3950	17	2
1903 Jan 1	To Stock	b/d	248	1	2						

If, when tried by the touchstone of the standard rate of gross profit, an actual rate appear erroneous, we may be sure that, whatever the source of the discrepancy, it is of sufficient importance to warrant an attempt to locate it. Sometimes a discrepancy can be shown to be the result of legitimate causes, and at other times the most determined efforts to unravel the mystery may prove unavailing.

Frequently, however, the knowledge that the actual rate of gross profit is false has led to the discovery of the fraud or error which it prognosticates.

A. J. WINDUS

SHORTHAND—LESSON 9. BY SIR ISAAC PITMAN & SONS

Grammalogues (Phonetically Arranged). Grammalogues marked "1" (first position) are written *above* the line. Those marked "3" (third position) are written *through* the line. Those not marked (second position) are written *on* the line.

CONSONANTS

P		happy 1; up; put 3
pn		upon
pr		principal, principle, principally 3
prt		particular 1; opportunity
B		by, buy 1; be; to be 3
bv		above
bn		been
br		remember-ed, member; number-ed 3
T		at 1; it; out 3
tlt		told
tr		try 1; truth; true 3
trts		towards
D		had 1; do; different-ce 3
dl		deliver-ed-y
df		advantage 1; difficult 3
dn		had been 1; done; down 3
dr		Dr 1; dear; during 3
CH		much 1; which; each 3
chl		children 1
J		large 1
jr		larger 1; journal
jl		largely 1
jn		general; religion 3
jnt		gentleman 1; gentlemen
K		can 1; come
kt		quite 1; could

knt		cannot 1
ks		because 1
kl		call 1; equal-ly
klt		called 1
kr		care
krt		according 1
G		go, ago 1; give-n
grt		great
F		if
fr		for
fr		from
fn		Phonography
V		have
vr		over 1; ever-y; however 3
vr		very
TH		thank-ed 1; think
*th*r		through, threw 3
TH		though 1; them, they
tht		that 1; without
ths		those 1; this; these 3
thr		other
thr		their, there, they are 1
thr		therefore 3 (double length)
S		so, us; see 3
s		as, has 1; is, his
st		first
sprt		spirit

sv		several
Z		was; whose 3
SH		shall, shalt
shrt		short 1
ZH		usual-ly
zhr		pleasure
M		me, my 1; him, may
ms		myself 1; himself
mp		important, importance 1; improve-d-ment
mr		more, remark-ed 1; Mr., mere
N		in, any 1; no, know
nt		not 1
nd		hand 1; under
nn		opinion
nr		nor, in our 1; near
NG		language 1; thing
L		Lord
R		or 1; your; year 3
r		are; hour, our 3
rd		word
W		we
wn		one
wl		will
Wh		whether
whl		while 1
Yt		yet

VOWELS

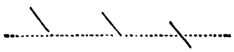
Dash		and (up)
ă		a, an
ah		ah!
ĕ		the
eh		eh? ay
ŏ		of
		on
aw		all
		awe
ŭ		but
oh		O! oh! owe
Dash		he
ŏŏ		to
		should (up)
oo		two, too
		who

DIPHTHONGS

wĕ		when
wĭ		with
wŏ		what
woo		would
yŏ		beyond
yŏŏ		you
ī		I, eye
ai		aye
ow		how
wi		why

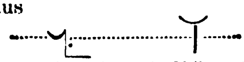
The POSITIONS of the logograms, ABOVE, ON, and THROUGH the line, are in general determined by the vowels contained in the words; and if a word has more than one syllable, by its accented vowel. The signs for grammalogues containing a *first-place* vowel are written *above* the line;

those with a *second-place* vowel on the line; and those with a *third-place* vowel through the line; thus



happy, up, put.

A logogram may be used either as a prefix or suffix; thus



undertake, indifferent.

Irregular grammalogues are of two descriptions, namely

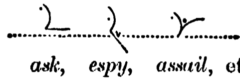
1. Those of frequent occurrence, written ON THE LINE for convenience. These are

are	have	usual
be	if	was
been	it	we
dear	Lord	which
deliver	Phonography	will
do	shall	your
for	think	
from	upon	

2. Those which, in their proper position, would clash with (*i.e.*, be mistaken for) some others. These are

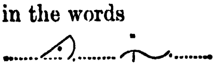
any 1	much 1	this
ago, go 1	number-ed 3	those 1
in 1	O! oh! owe 1	though 1
me 1	over 1	truth
more 1	particular 1	with 1

Writing in Position. When writing very rapidly it is impossible to insert many vowels. This has been recognised throughout, and the rules of the system have been formulated, as far as possible, with a view to the *indication* of the vowels when they are omitted. Thus, for example, it is provided that where there is an initial vowel there must be an initial stroke consonant, as in the words



ask, espy, assail, etc.

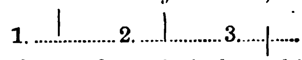
And, in the same way, where there is a final vowel there must also be a final stroke consonant, as in the words



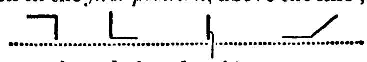
racy, money, etc.

In these and similar words the presence of an initial or final vowel is *indicated* by the outline of the word, without actually writing the vowel sign.

In addition to the foregoing methods of vowel signification, there is the writing of consonantal outlines in *position*, by which it is possible to indicate the vowel or the principal vowel in a word. The positions are named respectively *first position, second position,* and *third position;* the first being *above* the line, the second *on* the line, and the third *through* the line, thus

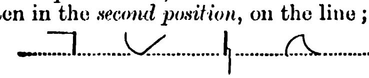


When the vowel or principal vowel in a word is a *first-place* vowel, the outline for the word is written in the *first position*, above the line; thus



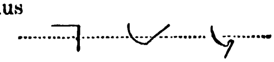
gaudy, dock, daughter, carry.

When the vowel or principal vowel in a word is a *second-place* vowel, the outline for the word is written in the *second position*, on the line; thus



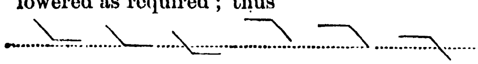
code, fairy, debtor, loaf.

When the vowel or principal vowel in a word is a *third-place* vowel, the outline for the word is written in the *third position*, through the line; thus



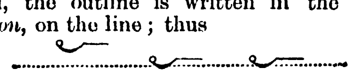
keyed, fury, voucher.

In words consisting of a horizontal letter preceded or followed by an upright or sloping letter, the latter determines the position of the outline, the horizontal letter being raised or lowered as required; thus

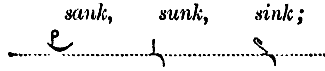


pack, peck, pick; cap, cape, keep.

There is no *third position* for words whose outlines consist of horizontal letters only, or of half-sized letters only, or of horizontal letters joined to half-sized letters. When the vowel or principal vowel in such words is a third-place vowel, the outline is written in the *second position*, on the line; thus

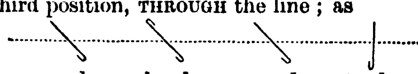


sank, sunk, sink;



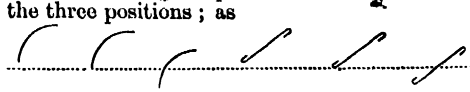
standing, tendered, splintered.

Double-length downstrokes take only the third position, THROUGH the line; as



ponder, plunder, pounder, tender.

A double-length upstroke can be written in the three positions; as



latter, letter, litter; wander, wonder, winter.

The student will meet with instances where there is a liability of clashing unless a vowel is inserted. He should vocalize freely rather than run the risk of illegibility.

Addition, Subtraction, Multiplication, and Division of Recurring Decimals. Simple and Compound Practice.

RECURRING DECIMALS & PRACTICE

RECURRING DECIMALS

94. In some cases of division, when the quotient is expressed as a decimal, we have found that the quotient does not terminate—for example, Art. **33**, Ex. **2**.

In such cases, a digit, or set of digits, is repeated continually. The decimal fraction is then called a *recurring*, a *repeating*, or a *circulating* decimal.

The digits which recur are called the *period*.

A *pure* recurring decimal is one in which the period begins immediately after the decimal point. Thus $\cdot3636\ldots$ and $\cdot7777\ldots$ are pure recurring decimals.

A *mixed* recurring decimal is one in which the period does not begin immediately after the decimal point. Thus $\cdot23548548\ldots$, in which the digits 548 recur but 23 does not recur, is a mixed recurring decimal.

The period is usually indicated by placing a dot over its first and last digits, so that $\cdot363636\ldots$ is represented by $\cdot\dot{3}\dot{6}$, $\cdot777\ldots$ by $\cdot\dot{7}$, and $\cdot23548548\ldots$ by $\cdot23\dot{5}4\dot{8}$.

95. We can easily tell, without performing the division, whether a vulgar fraction *in its lowest terms* will give a terminating or a repeating decimal; for a terminating decimal is equivalent to a vulgar fraction with 10, or some power of 10, as its denominator. Hence, if we can multiply both numerator and denominator of our vulgar fraction by such a number that the denominator becomes 10, or some power of 10, then the fraction will give a terminating decimal. Now 2 and 5 are the only numbers which can be multiplied so as to become powers of 10. Therefore, if the denominator of the given fraction contains any prime factors which are not either 2's or 5's, the fraction will not form a terminating decimal.

96. Further, we can tell the greatest possible number of digits in the recurring period. Consider the fraction $\frac{2}{7}$. When dividing by 7 the remainder must always be less than 7, so that the only possible remainders are 1, 2, 3, 4, 5, 6. Hence, the next remainder *must* be one which we have already had, and the figures in the quotient will recur, even if they have not done so sooner.

Although the following statements cannot be proved here, a knowledge of them may save much labour.

(1) When the denominator is a prime number, the number of digits in the period is a factor of the denominator-diminished-by-one.

Thus $\frac{1}{13}$ must recur after 1, 2, 3, 4, 6, or 12 digits, since these are the only numbers which are factors of 13 − 1, *i.e.*, of 12.

(2) By division we find $\frac{1}{7} = \cdot\dot{1}4285\dot{7}$. In any multiple of $\frac{1}{7}$, such as $\frac{5}{7}$, these same digits will form the period, and they will follow one another in the same order. By dividing 7 into 50 we see the first digit is 7; hence, we at once know that $\frac{5}{7} = \cdot\dot{7}1428\dot{5}$. This statement is true for any fraction whose denominator is prime, and *the number of digits in whose period is one less than this denominator.*

(3) In $\cdot\dot{1}4285\dot{7}$ we see that, when we have found the first half of the period by division, we can obtain the second half by subtracting the digits already found, in order, from 9. Thus, $8 = 9 - 1$, $5 = 9 - 4$, $7 = 9 - 2$. This fact is of great use in cases such as $\frac{1}{17}$, $\frac{2}{19}$, etc.

For example, we find by division that $\frac{1}{17} = \cdot05882352\ldots$ and that the quotient does not yet recur. But, by (1) of the present article, since it does not recur after *eight* figures, we know that it *must* recur after 16. Consequently, we can obtain the remaining 8 figures by subtracting the first 8, in order, from 9. Hence, $\frac{1}{17} = \cdot\dot{0}58823529411764\dot{7}$.

97. A pure circulating decimal is converted into a vulgar fraction as follows:

Example **1**. Reduce $\cdot\dot{2}$ to a vulgar fraction.

We have $\cdot\dot{2} = \cdot2222\ .\ .\ .\ .\ .\ .\ .\ .$ (1)

There is *one* digit in the period, so we multiply by the *first* power of 10.

Thus $10 \times \cdot\dot{2} = 2\cdot2222\ .\ .\ .\ .\ .\ .\ .$ (2)

Subtract (1) from (2), and we get

$$9 \times \cdot\dot{2} = 2$$

Therefore $\cdot\dot{2} = \frac{2}{9}$ *Ans.*

Example **2**. Reduce $\cdot\dot{7}1428\dot{5}$ to a vulgar fraction.

$$\cdot\dot{7}1428\dot{5} = \cdot714285714285\ .\ \ .\quad (1)$$

There are *six* digits in the period, so we multiply by the *sixth* power of 10.

Then

$$1000000 \times \cdot\dot{7}1428\dot{5} = 714285\cdot714285\ .\ \ .\quad (2)$$

Subtract (1) from (2) and we get

$$999999 \times \cdot\dot{7}1428\dot{5} = 714285.$$

Therefore,

$$\cdot\dot{7}1428\dot{5} = \frac{714285}{999999} = \frac{5 \times 142857}{7 \times 142857} = \frac{5}{7} \textit{ Ans.}$$

Hence we have the rule: *For the numerator, write down the digits which form the period; for the denominator, put down as many nines as there are digits in the period.*

98. Mixed recurring decimals are converted in a similar way.

Example. Reduce $\cdot3\dot{5}\dot{7}$ to a vulgar fraction.

$$\cdot3\dot{5}\dot{7} = \cdot3575757\ .\ \ .\ \ .\ \ .$$

There is *one* digit in the non-recurring part, so we multiply by 10, and obtain

$$10 \times \cdot 3\dot{5}\dot{7} = 3\cdot 575757 \;.\;.\;.\;.\quad (1)$$

There are *three* digits in the non-recurring part and the period together. Multiply, therefore, by the *third* power of 10.

$$1000 \times \cdot 3\dot{5}\dot{7} = 357\cdot 5757 \;.\;.\;.\;.\quad (2)$$

Subtract (1) from (2):

$$990 \times \cdot 3\dot{5}\dot{7} = 357 - 3.$$

Hence $\quad \cdot 3\dot{5}\dot{7} = \dfrac{357-3}{990} = \dfrac{354}{990} = \dfrac{59}{165}$ *Ans.*

We have, therefore, the rule: *For the numerator, write down the number consisting of the digits as far as the end of the first period, and subtract the number consisting of the digits which do not recur; for the denominator, write as many nines as there are recurring digits, followed by as many noughts as there are non-recurring digits.*

99. A decimal whose period is 9 is equivalent to a terminating decimal.

Example. By the above rule

$$\cdot 12\dot{9} = \frac{129 - 12}{900} = \frac{117}{900} = \frac{13}{100} = \cdot 13.$$

Or, the same thing may be shown by subtracting $\cdot 12\dot{9}$ from $\cdot 13$, the result being zero.

NOTE. From this it appears that $\cdot\dot{9} = 1$. This is only true in the sense that the difference between 1 and ·999... becomes less and less as we take more figures of the decimal, until the difference between them is smaller than any assignable quantity. It is, in fact, in this sense that any vulgar fraction is said to be *equal* to a recurring decimal.

100. Addition and Subtraction of Recurring Decimals.

In adding or subtracting recurring decimals, it should be noticed that we can always write the decimals so that their *periods begin at the same decimal place.* For, it is evident that $\cdot 1\dot{2}93\dot{4}$ may be written $\cdot 1293\dot{4}9\dot{3}$, since each is equivalent to ·12934934934... We have thus shifted the beginning of the period from the third place to the fifth.

Next, a decimal which has a period of, say, 4 digits, may be considered as having a period of 8, 12, or any other multiple of 4 digits. So that, if we have three decimals, whose periods consist of, say, 2, 3, and 4 digits, we may take the L.C.M. of 2, 3, 4, *i.e.*, 12, and consider that each decimal has a period of 12 digits.

We will now consider examples in addition and subtraction.

Example 1. Add together $\cdot 25\dot{7}9\dot{3} + \cdot 124\dot{6}\dot{1} + \cdot\dot{3}2\dot{5} + \cdot 1\dot{2}\dot{4}$.

$$\begin{array}{r|l|l}
\cdot 257 & 937937 & 93 \\
124 & 616161 & 61 \\
\cdot 325 & 325325 & 32 \\
\cdot 124 & 242424 & 24 \\
\hline
832 & \dot{1}2184\dot{9} & \textit{Ans.}
\end{array}$$

EXPLANATION. The latest place at which a period begins is the *fourth* (in the second decimal). We therefore, after writing the decimals under one another as in ordinary addition, draw a line in front of the *fourth* place. Next we see that the numbers of digits in the periods are 3, 2, 3, 2 respectively. The L.C.M. of these numbers is 6. Write, then, in each decimal, *six* figures to the right of the line we have drawn, and draw another line after them. Evidently the figures enclosed between the two vertical lines will continually repeat, so that we only need write down two more places of each decimal, in order to find what figure we must "carry," and add the decimals together. The answer will be a decimal of which the part between the vertical lines recurs.

Example 2. Subtract $\cdot 63\dot{5}6\dot{4}$ from $1\cdot\dot{8}7796\dot{8}$.

$$\begin{array}{r|l|l}
1\cdot 87 & 796887 & 79 \\
\cdot 63 & 564564 & 56 \\
\hline
1\cdot 24 & 232323 &
\end{array}$$

Reqd. difference $= 1\cdot 24\dot{2}\dot{3}$ *Ans.*

EXPLANATION. Make both decimals begin to recur at *third* place. Draw a line in front of the third place. The periods consist of 6 and 3 digits respectively. The L.C.M. of 6 and 3 is 6. Hence, write six figures to the right of the line, draw another line, and continue two places beyond. In this case there is nothing to "carry" from these extra places, and we get for our answer 1·24|232323|, where the figures between the lines form the period. We notice that this period of *six* figures consists of three sets of *two* figures, so that the answer is written $1\cdot 24\dot{2}\dot{3}$.

101. Multiplication and Division of Recurring Decimals.

Division by a whole number or by a terminating decimal presents no more difficulty than the division explained in Art. 33. We have, of course, to "bring down" the digits which form the period, instead of bringing down 0's.

Example 1. Divide $12\cdot\dot{0}\dot{6}$ by 3·7.

```
37 ) 120·606060... ( 3·259623 Ans.
      96
       220
        356
         230
           86
           120
             9
```

EXPLANATION. We have to divide 12·0606... by 3·7, *i.e.*, 120·606... by 37. Proceeding as in ordinary division, we find, after getting six figures of the quotient, that we obtain a remainder 12. This, with the 0 brought down from the dividend, gives 120, and we have already divided 37 into 120, at the beginning of the work. In the first case, however, the division did not give a digit in the *decimal* part of the quotient, so we have to proceed one step further, obtaining 3 in the quotient and 9 remainder. It is clear that all the digits in the decimal part of the quotient will now recur. Hence the answer is $3\cdot\dot{2}5962\dot{3}$.

Example 2. Multiply $4\cdot\dot{2}1\dot{3}$ by 3·25.

In multiplication by a whole number or by a terminating decimal, we write down the multiplicand as far as the end of two periods, and then two places more, so as to "carry" the correct figure. Write the multiplier with its unit's digit under the last digit of the second period, and proceed as in ordinary multiplication.

Thus:

$$\begin{array}{r|l|l|l}
4\cdot & 213 & 213 & \mathit{21} \\
 & & & 3\cdot 25 \\
\hline
12 & 639 & 639 & 6 \\
 & 842 & 642 & 6 \\
 & 210 & 660 & 6^{*} \\
\hline
13\cdot 692 & 942 & &
\end{array}$$

Or, $13\cdot 69\dot{2}9\dot{4}$ *Ans.*

N.B. It must be remembered that the last two places of the multiplicand are only used to enable us to carry the correct figure. Thus, in multiplying by 5, we say, five 1's, 5; but *we put nothing down.* Then

five 2's, 10, and again put nothing down; but we now know we must add-in the 1 carried, when we begin the multiplication of the period —*i.e.*, five 3's, 15, and 1, 16. This 6, according to the ordinary rule, would come *under the multiplier* 5, and is not needed in the above example. We proceed, five 1's, 5, and 1, 6; which is the 6 marked * in the working. Again, if there are many digits in the multiplier, it *may* be necessary to fill in one or two more periods of each separate product before adding them together. Thus, in the above example, had there been many more lines of multiplication, we might have had to continue the 639 of the first line, the 642 of the second, the 660 of the third, and so on, in order to find the period of the sum of all the lines.

102. If the multiplier is a recurring decimal, we *usually* express it as a vulgar fraction. In some examples the work is simpler if we also express the multiplicand as a vulgar fraction, in which case we proceed as in multiplication of fractions and then convert the result into a decimal. The student must use his judgment as to which method is best suited to any particular example.

The same remarks apply to division by a recurring decimal.

Example 1. Multiply $3\cdot\dot{1}4285\dot{7}$ by $\cdot\dot{6}\dot{3}$.

Here it is simpler to reduce both to vulgar fractions.

For $\quad 3\cdot\dot{1}4285\dot{7} = 3\frac{1}{7}$

and $\quad \cdot\dot{6}\dot{3} = \frac{63}{99}$

Their product $\quad \frac{\cancel{22}^{\,2}}{\cancel{7}} \times \frac{\cancel{63}^{\,\cancel{7}}}{\cancel{99}_{\,\cancel{9}}} = \underline{2\ \textit{Ans.}}$

Example 2. Divide $3\cdot\dot{1}2\dot{8}$ by $1\cdot\dot{3}$.

The divisor $= 1\frac{3}{9} = 1\frac{1}{3} = \frac{4}{3}$. To divide by $\frac{4}{3}$ we multiply by $\frac{3}{4}$.

Thus:

$$\begin{array}{r} 3\cdot12812\ldots \\ 3 \\ \hline 4\overline{)9\cdot\dot{3}8\dot{4}} \\ 2\cdot346\dot{0}9\dot{6}\ \textit{Ans.} \end{array}$$

EXAMPLES 12

1. Add together $3\cdot12\dot{6}\dot{4} + \cdot008\dot{3} + 10\cdot9\dot{6}1\dot{4}$.

2. Find the value of $7\cdot1\dot{2}3\dot{4} - \cdot\dot{0}25\dot{7} + 3\cdot54\dot{3}2\dot{1} + 11\cdot257 - 9\cdot\dot{3}\dot{6}$.

3. Express $2\cdot25\dot{2}85714\dot{4}$ as a vulgar fraction in its lowest terms.

4. Express £15 13s. $7\frac{1}{2}$d. as the decimal of £99 6s. $3\frac{1}{2}$d.

5. Find the value of $\cdot1\dot{3}\dot{6}$ of £7 14s. 11d. − $\cdot025\dot{4}$ of £6 0s. $3\frac{3}{4}$d.

6. Simplify, giving the answer as a decimal, $\cdot7\dot{3}$ of $1\cdot\dot{2}3\dot{4}$ of 12.

7. Show that the decimals equivalent to $\frac{1}{7}$, $\frac{2}{7}$, $\frac{3}{7}$, $\frac{4}{7}$, $\frac{5}{7}$, $\frac{6}{7}$, can be arranged in a square so that the sum of each row, of each column, and each diagonal, is the same.

8. Find the greatest decimal fraction which, when divided into $\cdot13\dot{6}$ and into $\cdot\dot{8}\dot{2}$, gives a whole number for quotient in each case.

9. A warehouse consists of three floors; the rent of each floor is $\cdot\dot{8}\dot{1}$ of the rent of the floor below; that of the top-floor is £51 6s. What is the rent of the ground floor?

10. A train puts down $\cdot\dot{3}8461\dot{5}$ of its passengers at its first stop, and 57 people at its second stop. It now has $\frac{1}{2}$ of the original number left. How many passengers were there when the train started?

PRACTICE

103. Practice is a convenient method by which we find the value of any quantity when we know the value of one of the units in terms of which the quantity is expressed.

In *simple* practice we have to find the value of a *simple* quantity; in *compound* practice, the value of a *compound* quantity.

The method is as follows:

In simple practice we break up the value of a single unit into component parts, each of which *measures* [see Art. 57] one of the preceding component parts. It is then easy to obtain the value of the given quantity when the value of a unit is each of these component parts, in turn; after which, we add the several results.

In compound practice we break up the given compound quantity into components in the same way, and, after finding the value of each component, we add the results.

Such components are called *aliquot parts*. Thus, an aliquot part of a quantity is a part which measures that quantity, and therefore it is a fraction of the quantity whose numerator is 1.

Examples.

3s. 4d. is an aliquot part of £1, since 3s. 4d. $= \frac{1}{6}$ of £1.

14 lb. is an aliquot part of 1 cwt., since 14 lb. $= \frac{1}{8}$ of 1 cwt.

104. A few examples will make the method clear.

Example 1. Find the value of 3128 tons at £1 8s. 6d. per ton.

Here we have a simple quantity, *viz.*, 3128 tons, and we are given the value of a unit.

The work is arranged thus:

	£	s.	d.	
5s. $= \frac{1}{4}$ of £1	3128	0	0	= cost at £1 per ton
3s. 4d. $= \frac{1}{6}$ of £1	782	0	0	= „ 5s. „
2d. $= \frac{1}{20}$ of 3s. 4d.	521	6	8	= „ 3s. 4d. „
	26	1	4	= „ 2d. „
	4457	8	0	*Ans.*

EXPLANATION. The cost of 3128 tons at £1 per ton is evidently £3128. Next, 5s. $= \frac{1}{4}$ of £1, and therefore the cost at 5s. a ton will be one quarter of the cost at £1, so that we obtain the cost at 5s. by dividing £3128 by 4. Again, 3s. 4d. $= \frac{1}{6}$ of £1, therefore, divide the cost at £1 by 6 to obtain the cost at 3s. 4d. Similarly, since 2d. $= \frac{1}{20}$ of 3s. 4d., we divide the cost at 3s. 4d. by 20 to obtain the cost at 2d. Finally, we add the several costs, *viz.*, at £1, at 5s., at 3s. 4d., and at 2d. to obtain the cost at £1 8s. 6d.

Example 2. Find the cost of $7692\frac{1}{2}$ articles at £3 16s. $4\frac{1}{2}$d. each.

	£	s.	d.	
10s. = $\frac{1}{2}$ of £1	7692	5	0 =	cost at £1 each
			3	
	23076	15	0 =	„ £3 „
5s. = $\frac{1}{2}$ of 10s.	3846	2	6 =	„ 10s. „
1s. 3d. = $\frac{1}{4}$ of 5s.	1923	1	3 =	„ 5s. „
$1\frac{1}{2}$d. = $\frac{1}{10}$ of 1s. 3d.	480	15	$3\frac{3}{4}$ =	„ 1s. 3d. „
	48	1	$0\frac{3}{8}$	„ $1\frac{1}{2}$d „
	£29374	15	$7\frac{1}{8}$	*Ans.*

* In dividing the previous line by **10**, we obtain 3d. remainder from the pence. This, with the $\frac{3}{4}$d. makes $\frac{15}{4}$d., and $\frac{15}{4} \div 10 = \frac{15}{40} = \frac{3}{8}$d.

Sometimes the work is considerably shortened if we *subtract* one or more aliquot parts, as in the next example.

Example **3**. Find the cost of 107 things at £17 17s. $10\frac{1}{2}$d. each.

Here, the value of each article is 2s. $1\frac{1}{2}$d. short of £18. We find the cost at £18, and subtract the cost at 2s. $1\frac{1}{2}$d.

	£	s.	d.	
2s. = $\frac{1}{10}$ of £1	107	0		= cost at £1 each
	321	0		
	1926	0	0 =	£18
$1\frac{1}{2}$d. = $\frac{1}{16}$ of 2s.	10	14	0 =	2s.
		13	$4\frac{1}{2}$ =	$1\frac{1}{2}$d.
	£1914	12	$7\frac{1}{2}$	*Ans.**

* Subtract the two lines from £1926 by the method of Art. **43**.

Example **4**. Find the cost of 4 tons 12 cwt. 80 lb. at £3 15s. per ton.

	£	s.	d.	
10 cwt. = $\frac{1}{2}$ of 1 ton	3	15	0	= cost of 1 ton
			4	
	15	0	0 =	„ 4 tons
2 cwt. = $\frac{1}{5}$ of 10 cwt.	1	17	6 =	„ 10 cwt.
70lb. = $\frac{1}{16}$ of 10 cwt.		7	6 =	„ 2 cwt.
10 lb. = $\frac{1}{7}$ of 70 lb.		2	$4\frac{1}{8}$ =	„ 70 lb.
			$4\frac{1}{56}$ =	10 lb.
	£17	7	$8\frac{1}{7}$	*Ans.*

Example **5**. Find the cost of 15 miles 6 fur. 200 yd. at £31 6s. 8d. per mile.

Here 240 yd. more would make 16 miles. Therefore, we have :

	£	s.	d.	
160 yd. = $\frac{1}{11}$ of 1 mile	31		8	= cost of 1 mile
			4	
	125	6	8	
			4	
	501		8	„ 16 miles
80 yd. = $\frac{1}{2}$ of 160 yd.			$11\frac{7}{11}$	„ 160 yd.
	1	8	$5\frac{9}{11}$ =	„ 80 yd.
By subtraction	£497	1	$2\frac{6}{11}$	*Ans.*

EXAMPLES 13

1. Find the cost of 3256 head of cattle at £14 17s. 10d. per head.

2. Find the value of $729\frac{1}{2}$ dozen walking-sticks at £3 4s. $7\frac{1}{2}$d. per dozen.

3. What will it cost to fence 6 fur. 72 yd. at £3 15s. a furlong ?

4. A bankrupt pays 14s. $5\frac{1}{2}$d. in the £. How much will a creditor receive to whom the bankrupt owed £743 10s. ?

5. Find the value of 743·875 oz. of silver at 2s. 8d. per oz.

6. Find in £ s. d. the value of 32·8625 of £3 11s. 4d.

7. What will be the rent of 5 ac. 6 sq. ch. at £4 2s. 6d. per acre ?

8. Find the cost of 33 miles 5 fur. 180 yd. of telegraph wire, at £12 13s. 6d. per mile.

9. What is the value of 1 ton 15 cwt. 91 lb. at £1·4625 per cwt. ?

10. Find the cost of 1 a. 3215 sq. yd. at 2s. $2\frac{1}{2}$d. per sq. ft.

11. Find, by Practice, the value of 2214 times £1 11s. $4\frac{1}{2}$d.

12. Find the cost of constructing 5 mls. 5 fur. 10 chains of road, at £2376 per mile.

Answers to Arithmetic

Examples 12

1. $14{\cdot}096\dot{2}5944\dot{1}$.

2. $21{\cdot}92\dot{3}\dot{6} - 9{\cdot}\dot{3}89\dot{3} = 12{\cdot}53\dot{4}29\dot{7}$.

3. $2{\cdot}25\dot{2}8571\dot{4} - 2{\cdot}25 + {\cdot}00\dot{2}8571\dot{4} = 2\frac{1}{4} + \frac{2}{700}$ $= 2\frac{177}{700}$.

4. Reduce both sums to halfpence. Then, required fraction $= 7527 \div 47671 = \frac{3}{19}$ $= {\cdot}\dot{1}5789473684210526\dot{3}$. (Apply Art. **96** (3) to obtain the last nine digits of the period.)

5. ${\cdot}1\dot{3}\dot{6}$ of £7 14s. 11d. $-$ ${\cdot}02\dot{5}\dot{4}$ of £6 0s. $3\frac{3}{4}$d. $= \frac{3}{22}$ of £7 14s. 11d. $-$ $\frac{7}{275}$ of £6 0s. $3\frac{3}{4}$d. = £1 1s. $1\frac{1}{2}$d. $-$ 3s. $0\frac{3}{4}$d. = 18s. $0\frac{3}{4}$d.

6. ${\cdot}7\dot{3}$ of $1{\cdot}\dot{2}3\dot{4}$ of $12 = \frac{11}{15}$ of $14{\cdot}\dot{8}1\dot{0} = 11 \times {\cdot}\dot{9}87\dot{3} = 10{\cdot}\dot{8}61\dot{2}$.

7. $\frac{2}{7} = {\cdot}\dot{2}8571\dot{4}$; $\frac{1}{7} = {\cdot}\dot{1}4285\dot{7}$; $\frac{3}{7} = {\cdot}\dot{4}2857\dot{1}$; $\frac{4}{7} = {\cdot}\dot{5}7142\dot{8}$; $\frac{6}{7} = {\cdot}\dot{8}5714\dot{2}$; $\frac{5}{7} = {\cdot}\dot{7}1428\dot{5}$. Write the decimals under one another in this order.

8. ${\cdot}13\dot{6} = \frac{123}{900}$, ${\cdot}\dot{8}\dot{2} = \frac{82}{99}$. Reduce these fractions to their least common denominator, obtaining $\frac{1353}{9900}$ and $\frac{8200}{9900}$. The required greatest divisor will have 9900 denominator, and the H.C.F. of 1353 and 8200 for numerator.

$$\therefore \text{ Ans.} = \frac{41}{9900} = {\cdot}00\dot{4}\dot{1}$$

9. ${\cdot}\dot{8}\dot{1} = \frac{81}{99} = \frac{9}{11}$. Hence, the rent of each floor is $\frac{11}{9}$ of the rent of the floor above. $\therefore$ ground floor rent $= \frac{11}{9} \times \frac{11}{9} \times$ £51 6s. = £76 12s. 8d.

10. ${\cdot}\dot{3}8461\dot{5} = \frac{5}{13}$. Hence, $(1 - \frac{5}{13} - \frac{1}{4})$ of the original number is 57. Or 57 passengers $= \frac{19}{52}$ of the original number.

$$\therefore \text{ Original number } = \frac{52}{19} \times 57 = 156.$$

Examples 13

1. £48487 5s. 4d.	**7.** £23 2s.
2. £2357 3s. $11\frac{1}{4}$d.	**8.** £427 9s. $10\frac{4}{11}$d.
3. £23 14s. $6\frac{6}{11}$d.	**9.** £52 7s. $6\frac{3}{16}$d.
4. £537 9s. $9\frac{1}{4}$d.	**10.** £8004 13s. $1\frac{1}{2}$d.
5. £99 3s. 8d.	**11.** £3473 4s. 3d.
6. £117 4s. $2\frac{3}{10}$d.	**12.** £[illegible]3,572 18s.

H. J. ALLPORT

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IS THE BLOOD ALIVE? The millions of living cells in it

THE RECORD OFFICE OF A HUMAN LIFE. A study of memory as a system, with millions of pigeon-holes in which facts and thoughts are stored.

FIRST AID. A lesson in stopping bleeding.

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The Children's Magazine, with which a children's newspaper is given away free each month, is

THE SIMPLEST BOOK OF KNOWLEDGE EVER WRITTEN

THE [illegible]NE FOR ALL AT HOME

The Children's Magazine is the most famous educational magazine in the world. It is loved as much by teachers as by children. **It is probable that no other book published for boys and girls has ever been so much read by people of all ages.**

And the reason is plain, for the Children's Magazine—so named not because it is childish, but because a child can understand it—**tells the story of all things under the sun in the plainest words that can be written.** It looks out upon the world and sees the wonder of a common thing. It looks back into the past and sees the things that were making the present ; it looks out upon the present and sees the things that are making the future ; it looks out into the future with faith and hope, as a man with a vision. **It has in its pages, from beginning to end, the faith of the men who have made the Self-Educator.**

It covers the whole realm of knowledge ; it embraces history, literature, Nature, biography, stories, poetry, travel, and science. In its pages we live in all times and places. Even its stories, while stirring the imagination, serve a purpose in shaping the mind.

No wonder the children love this magazine, that poor children save their halfpennies to buy it, that playful children give up their playtime to read it, that in a school in New Zealand children come half an hour before school-time to look at its pictures. **More than 10,000 children have sent their portraits to the editor.** We do not wonder that this great children's book has gone all over the world, nor do we wonder that fathers and mothers are as interested in it as the children. It makes a man wish he were a boy again. It makes every lover of children wish it were cheap enough for every child to possess.

Whatever else they may or may not have done, the makers of this book have put into it all that we mean by personality. Nothing is stale or dull ; everything is striking and picturesque. There are pictures here which make mysterious things seem plain, and make commonplace things seem romantic.

It would be possible to fill a book as big as the Bible with the remarkable letters this magazine has brought from educators and parents and children in all countries, but there is room for only a few.

EXTRACTS FROM [illegible]

Each one of the children of her Majesty the Queen is delighted with it and glad to possess it. *Authorised by Queen Mary.*

The Children's Magazine is a marvel, and I am not ashamed to say I can read it with profit and pleasure even now. *Richard Whiteing.*

A useful guide to adult students, and a pleasure to the most cultured scholar. *Sir Benjamin Stone.*

Every parent, every teacher, every clergyman will use it in education. *Sir William Treloar.*

I like it very much. My boy likes it still more. *Professor Osler.*

It makes an irresistible appeal to all the dawning faculties of childhood. *Sir J. Crichton-Browne.*

Probably the most delightful publication ever issued from the Press. *Sir Henry Burdett.*

I predict for it a great and useful future, and an assured position as a household word wherever English family life is to be found. *Archdeacon of Monmouth.*

The best possible educator since the discovery of printing. *C. S. Rae, J.P., Nassau, Bahamas.*

It should be in every school library, and in every home where there are children. *R. Fletcher, Department of Education, Manitoba.*

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The best production ever presented to the world for the education of children. *F. W. Fitzsimmons, Director, Port Elizabeth Museum.*

Worth all the other children's books and toys put together. *Board of Education Official.*

You have hit the right nail on the head. *Professor Sims Woodhead, Cambridge.*

The very thing I wanted when my bairns were little. *Mrs. Ormiston Chant.*

If you keep to your high promise, you are likely to have more effect on the education of the nation than many Acts of Parliament. *Benjamin Kidd.*

THE CHILDREN'S MAGAZINE, LYING WITH THE EDUCATOR ON THE BOOKSTALL, IS

THE BEST THING IN THE WORLD THAT SEVENPENCE CAN BUY

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A FESTIVAL DAY AT THE COLISEUM

THE GREAT AMPHITHEATRE OF ROME—FROM THE PAINTING BY SIR LAWRENCE ALMA-TADEMA, R.A.
By permission of the Berlin Photographic Company, London, W.

FACING PAGE 253

Shall Inclination or Circumstances Dictate? Average Talent to Succeed Must Do Something New

THE CHOICE OF A LIFE'S WORK

THE choosing of a career is not regarded so seriously nowadays as it was in the eighteenth century and well towards the end of the nineteenth. All who are interested in the welfare of our people will agree with me in describing this as an unfortunate feature of the social life of our time; for the result is becoming painfully evident in the number of young people one observes who are but indifferently equipped for their life-work. While general education has greatly advanced, it has not been so with the systematic study of individual tastes and qualifications in their application to the serious business of life.

For the professions, it is true, there is to be noted a more thorough system of preliminary training than in the past. One has only to instance the modern doctor to illustrate this. Beyond all question, he or she—for no longer is it a profession of one sex—is better educated than the doctor has been at any period in the history of society. But I am persuaded that we are unable to take so desirable a view of the crafts, and I venture to doubt if sufficient attention is devoted to the training for and choice of a career in any of our great national trades. The practical abolition of the old system of apprenticeship is, in the judgment of many shrewd observers, a misfortune.

Naturally, the prime factor in the choice of any career should be personal taste, inclination. But, unhappily, we have only to look around us to realise how frequently the natural inclination is ignored. The world is full of round pegs in square holes. Who does not know the man who might have been a capable engineer but is frittering his life away as an inferior clerk, doing work he detests? The engineer who might have been the organiser of a great warehouse; the lady typist who might have been a successful saleswoman, instead of an incompetent correspondent; the governess who would have made a clever typist and business woman—who is not familiar with such as these, round pegs in square holes? Occasionally one finds men who, in later life, have boldly broken away from servitude in occupations they had undertaken in error, or by force of circumstances, and have achieved success in their true vocations. Thus it is that instances of success in middle age and later life are by no means rare. But, of course, there are occasions when it may be wise for a person not to follow the bent of natural inclination and to join loyally in maintaining a business that has perhaps been long identified with his family. Indeed, there is so much room in the world for people of average talent to apply themselves profitably that it might, for instance, be advisable in the case of a young man whose father was a prosperous local practitioner to follow in his father's footsteps.

Heredity, undoubtedly, counts for something in the choice of a career, and often goes hand in hand with natural inclination. One thinks of families of successful statesmen, like the Cecils; of lawyers, like the Pollocks; and one remembers the two Pitts in statesmanship, the Stephensons in engineering. In other walks of life there are whole families of mechanics, carpenters, builders, and the like, known to most of us. In this connection, it is worthy of remark that one of the great difficulties which our American cousins have not been able to surmount in their efforts to wrest the cotton-spinning industry from us is the fact that they do not possess generations of trained workpeople such as we have in Lancashire.

Since there is no rule without its exceptions, one must not dare to dogmatise on this matter of heredity; but it is sufficiently clear that the volume of evidence in its behalf is so formidable that in the choice of a career it is a factor not to be ignored. There are times when it is well deliberately to disregard it—never to ignore it—but more often, by one of those curious traits of character which make the study of human beings so deeply interesting, sons revolt against the occupations of their fathers quite without adequate reason; and too frequently this leads to emigration. Now, in my

judgment, emigration is nearly always implied confession of failure.

We must, however, make an exception in the case of agricultural workers, for whom there is always a fair field beyond the seas. But the result of considerable personal investigation into colonial conditions in many parts of the empire has persuaded me that the man who succeeds in the colonies might, with equal effort, fare as well at home. I do not believe that the United Kingdom is overcrowded with people. Belgium has no greater facilities for industry than are to be found in our own land, and her population of over 7,000,000 people to 11,000 square miles brings Belgium not very far short of being twice as densely inhabited as the United Kingdom; yet it is true that the working classes of Belgium are among the most prosperous in Europe, in some respects being even better conditioned than our own working-classes.

A general fault in the choice of one's life-work is to follow blindly in the footsteps of some trade which, once profitable, may have ceased to be so; if not in imminent danger of extinction. Within the last few years, incredible though it may sound to those familiar with the unhappy conditions of the trade, I have met people learning wood-engraving; an occupation practically—and I regret to think so—dead. They had been articled to some wood-engraver by their parents, who had not taken the trouble to find out that this class of engraving was being superseded, has long been superseded, by the many cheaper and vastly quicker processes of photo-etching.

Thus far, I have referred mainly to occupations in which a reward in money is the first consideration, though that may be allied to genuine pleasure in the work. Of course, there are occupations in which the earning of money is not esteemed of prime importance. Those who approach music, painting, sculpture, literature, mainly with the idea of accumulating money thereby are not likely to succeed in their ambition. But it may be said of these pursuits that, followed professionally, they are affording to their professors increasing returns in the material rewards of life; while not less today than in times past do they minister to the highest and best that is in mankind. One is often asked, Who buys the modern pictures, and what becomes of the musicians? Well, there are more painters and musicians today in England than at any other time, and I do not find, on looking at the official reports of bankruptcies, that the arts are more dangerous than commercial occupations to those who engage in them.

Having chosen an occupation in life, one has next to consider a no less difficult question—the means of obtaining success. In some measure good fortune is possible to anyone who is blessed with health. For although all cannot be equally prosperous in their affairs, everyone can make some kind of mark. But not by travelling the old roads.

Education all the world over—I do not say the best education, but the kind of education that makes money—is increasing. As a result, brains work more rapidly, though perhaps not so thoroughly as they did in the past. In every direction we observe that men of active minds are breaking away from tradition and making fortunes by their boldness; in many cases they are doing this by actual reversal of the policy of their forefathers.

It is not, in my opinion—and I base my statement on knowledge of successful men in many lands—the young man who seeks an appointment in an old-fashioned business, and settles down doggedly to the humdrum, plodding work of doing his duty and observing precedent, who attains, even in the long run, to competency, far less to fortune. There are thousands of men in this and in every land who are hoping to make fortunes that way, and who never will. It is the man who goes into the shop, and, out of his own resourcefulness, his open and nimble mind, shows his employer how to sell new kinds of goods in new kinds of ways, that eventually becomes strong enough to enforce his demands to a share of that shop or some other shop. The new thing and the new way; or the old thing in a new way—either means success if there is persistent concentration behind.

But this young man must be well in body all the time, so that his mind may be free to devote itself to that prime secret of success—*concentration*. Fortunes come to audacious gamblers now and then, and such rare but disastrous examples do, I know, disturb the minds of young men; for every venture in life has, it must be admitted, at least some slight element of gambling. But, after all, *concentration of purpose* is the backbone of all success in the

world, be it that of the poet or of the pork-packer. He who has cultivated the habit of concentration looks round every proposition so thoroughly that he may be said to have, so far as is humanly possible, eliminated therefrom every element of risk that a man can suppress. The gambler is not only beset by risks, but seeks them; and the fate of the deliberate gambler in business is usually as dismal as that of the gambler in "play."

Finally, after concentration has brought about the initial success, optimism of temperament is necessary. It does much to carry with it those who are around one, associated in a common enterprise, and it brings with it that leadership which is so essential to success in every walk of life. When Ferdinand de Lesseps began to talk of cutting the Suez Canal, no one believed him, and, as a matter of fact, he was, as he himself confessed, on the wrong track at first. But gradually his forceful optimism persuaded individual after individual, and then nation after nation, that the thing could and should be done, and it was done, despite the belief of great engineers that the task was impossible. His career is an ideal one to study from the point of view of those who seek success. He may be said to have done an old thing in a new way—for had not the Ptolemies done it two thousand years before?—and he had concentrated his whole existence on it.

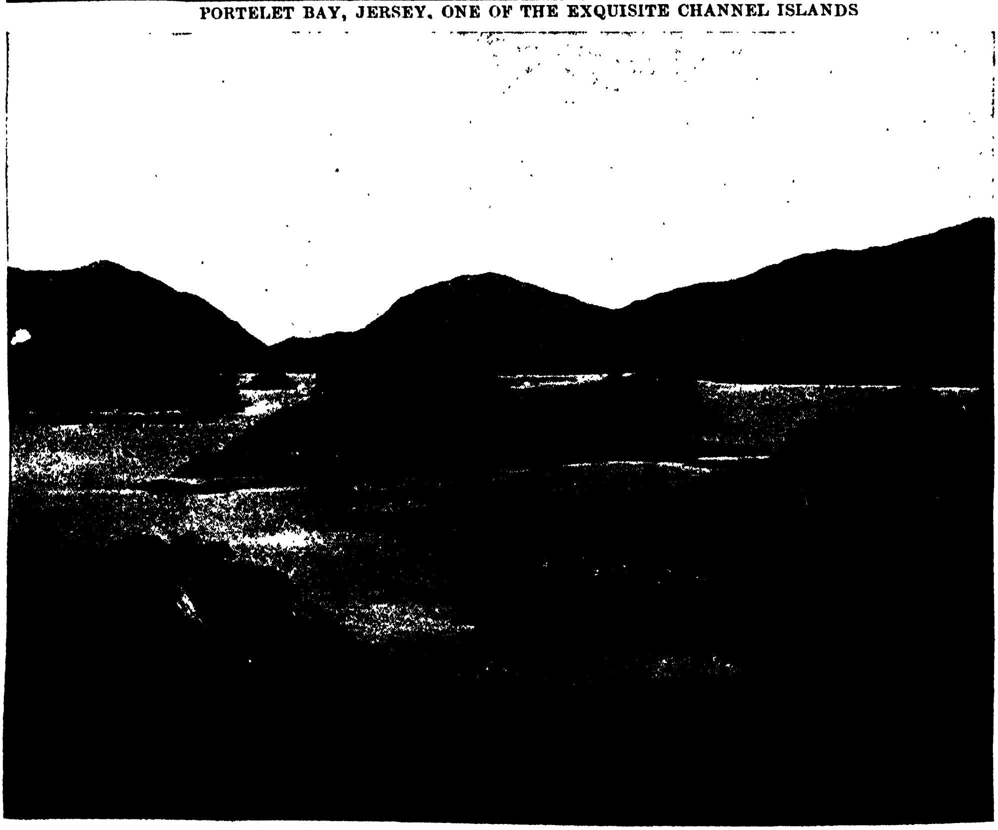
THE GREAT BELT OF SAND FROM PORT SAID TO SUEZ, WHICH THE INDOMITABLE COURAGE OF ONE MAN TRANSFORMED INTO A HIGHWAY OF THE WORLD'S COMMERCE

Let my last word strike this note of optimism, enthusiasm once more. Of nothing am I more firmly persuaded than that our own temperament is sure to help or hinder us in the struggle for success. To be nervously apprehensive of failure is literally to invite failure; but to be confident of success, or at any rate reasonably hopeful and determined not to contemplate the reverse, is already to have won half the battle.

NORTHCLIFFE

BEAUTY SPOTS OF OUR BRITISH ISLANDS

PORTELET BAY, JERSEY, ONE OF THE EXQUISITE CHANNEL ISLANDS



ISLANDS IN THE UPPER LAKE OF KILLARNEY, IRELAND

Physical Features. Growing Prosperity. Ulster and its Industries. Kerry Mountains and Lakes of Killarney. Isle of Man. Channel Islands.

IRELAND

In configuration Ireland is like a plate with a broken rim of mountains and a flat centre. On the east the rim is missing and the Midland Plain extends to the sea. Partly, perhaps, because of this arrangement of high and low land, much of Ireland is boggy, and lakes are numerous. A bog is something between land and water, made half-solid by dense, matted vegetation, which is cut and dried to form peat or turf. As there is hardly any coal in Ireland, peat forms the only cheap fuel. When bogs occur on hillsides the weight of water occasionally loosens their foundations, and a bog slide causes widespread ruin. In the plain many have been drained, and then the land, as in the English Fens, is generally fertile.

Ireland is not very populous. Owing to the absence of coal there is only one great industrial centre. The wet climate is not well suited for agriculture, but oats, barley, and potatoes are grown, the barley being malted, made into stout, and distilled into whisky. The rains keep its meadows luxuriantly green, giving the country the name of the Emerald Isle. Dairy farming and stock raising in the lowlands provide butter, bacon, poultry, and eggs for export. Through co-operation and more careful farming, the prosperity of the farmers is increasing rapidly. In the highlands the soil is scanty and of poor quality, the climate wet and raw, and the struggle for existence very hard. A whole family, with its few domestic animals, is often crowded into a cottage of one room, standing in the midst of a barren moorland croft. In many districts Irish is still spoken. From these congested western districts the more capable still emigrate.

Ireland is divided into Ulster in the north, the most prosperous region, with a large population of Scottish and Protestant descent; Leinster in the south-east, Munster in the south-west, and Connaught in the west. It is also divided into 32 counties. North of lat. 54° Ireland is mountainous. The highlands are not continuous, as in Scotland or Northern England, but broken into separate masses. In the lowlands between we find the towns and the more prosperous part of the population.

In the extreme west the Moy flows to Killala Bay, between the Nephin Beg and Slieve Gamph Mountains, with Ballina as the chief town. Between the Slieve Gamph and Sligo Mountains an arm of the Central Plain opens to Sligo Bay, on which is Sligo, a fishing centre. The Erne lowland, with its chain of lakes, the town of Enniskillen between Upper and Lower Lough Erne, and Ballyshannon on the estuary, opens to Donegal Bay, at the head of which is Donegal, between the Sligo and Donegal Mountains, both broad, high, barren, and poverty-stricken.

The prosperous Foyle lowland lies between Tyrone Mountains on the south, the Donegal Mountains on the west, and the Sperrin Mountains on the east. Omagh, Strabane, Lifford, and Londonderry are engaged in shirt-making and distilling. Londonderry, on the Foyle estuary, exports butter, pork, bacon, cattle, and grain to Liverpool and Glasgow, and imports timber and coal. Moville is a port of call for Atlantic liners. Equally prosperous is the Bann lowland, between the Tyrone and Sperrin Mountains on the east, and the Antrim and Mourne Mountains on the west. In the south it is drained by the Blackwater and Bann to Lough Neagh, the largest lake in Britain. Monaghan, Armagh, an old ecclesiastical centre, Dungannon, and Lurgan are the chief towns south of the lake, and north of it are Antrim and Ballymena. Lough Neagh is discharged by the Bann, with Coleraine as its port. The Antrim Plateau is of basalt, of which are formed the wonderful columnar terraces of the Giant's Causeway, east of Portrush. An important gap between the Antrim and Mourne Mountains, drained by the Lagan, has helped to make Belfast prosperous by giving it easy land routes to the plain.

Much more important is its situation on the coast, where coal can be cheaply obtained from the Ayrshire, Cumberland, and Lancashire coalfields, and raw

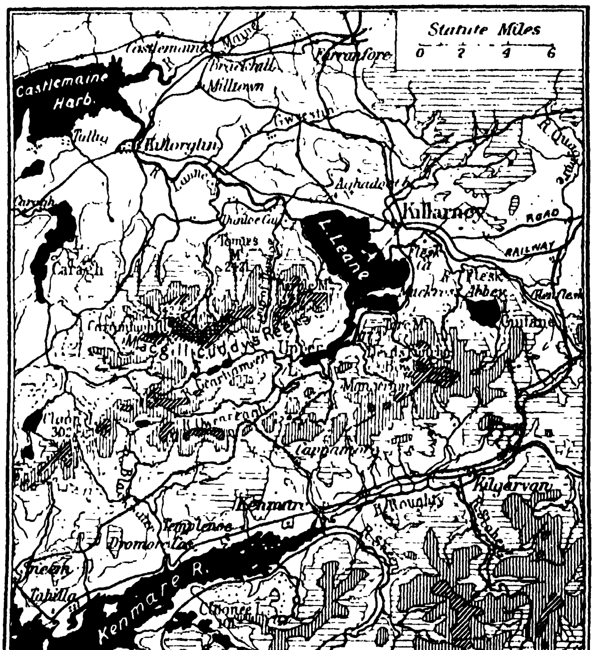
THE WESTERN HALF OF IRELAND

THE ATLANTIC-SWEPT SHORES OF ERIN, SHOWING THE CHARACTERISTIC WILDNESS OF THE COASTLINE AND THE COUNTIES WHICH ARE PERHAPS AMONG THE POOREST PARTS OF THE BRITISH EMPIRE

THE EASTERN HALF OF IRELAND

THE CHIEF INDUSTRIAL AREAS OF IRELAND, SHOWING THE POSITIONS OF THE MOST IMPORTANT COMMERCIAL TOWNS AND THE PRINCIPAL STEAMSHIP ROUTES TO GREAT BRITAIN

materials from the Baltic ports. The linen manufacture from home-grown and Baltic flax is very important. The damp climate favours spinning, and the water has fine bleaching properties. The importance of shirt-making in many Ulster towns is now explained. Rope-making from Baltic hemp employs many hands. Shipbuilding is carried on on a large scale, for the yards pay no rates and labour is cheap. Tobacco manufactures and distilling may also be noted. Belfast, therefore, resembles the prosperous manufacturing centres on the other side of the Irish Sea, but it stands alone in Ireland. Carrickfergus, on the north bank of Belfast Lough, has important fisheries. Larne is the port for the Stranraer route across the narrow North Channel. South of Belfast are Donaghadee, and Downpatrick on Strangford Lough. The granite Mourne Mountains, rising to nearly 3000 feet, are much visited for their fine scenery. To the south is Carlingford Lough, north of which Newry is built in the gap leading to Lough Neagh; Dundalk, on Dundalk Bay, an important railway centre with locomotive works, exports provisions; and Greenore has regular steamer communication with Holyhead.



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THE LAKES OF KILLARNEY

The higher the elevation, the darker the shading

West Highlands of Connaught. All these lowlands are connected with the Midland Plain, which extends from the Irish Sea to the mountains of Western Connaught. These are known as the Nephin Beg Mountains in the north, and the Connemara Mountains, with marble quarries, in the south, both rising to 2500 feet. The coast resembles that of the West Highlands of Scotland, with many inlets, of which the largest is Clew Bay; they are separated by fine cliffs and headlands. The life of the peasantry is very similar to that of the Highlanders, but even harder than theirs. Poor grazing is eked out by poor fishing, and cottage industries. At the eastern base of the highlands is a chain of lakes—Conn, Mask, and Corrib—at the edge of the limestone Midland Plain. Galway, south of Corrib, at the head of Galway Bay, which would be a flourishing port in a richer district, exports the dairy produce of the better pastures, marble, and fish.

The Midland Plain. The Midland Plain contains much good agricultural and meadow-land, but also much bog. The great Bog of Allen occupies a large part of King's County and Kildare. The Shannon, the largest river of Ireland, rises less than 300 feet above the sea, and flows slowly across the plain, the whole centre of which is drained by it and its tributaries. In its upper course it expands into Lough Allen, south of which are Leitrim and Carrick-on-Shannon. Below Carrick the Boyle enters from the west, flowing through boggy country, with similar lake-like expansions. The Shannon continues of lake-like breadth to Athlone, at the south of Lough Ree, always an important town, because the river is there narrow enough to be bridged. It is the place where the main line from Dublin to Galway crosses the river. Below Athlone the Shannon expands to Lough Derg, and then flows through the gorge of Killaloe, between the Bernagh and Silvermine Mountains, to its estuary, at the head of which is Limerick, with a large provision trade, and some lace manufactures. West of the Shannon basin the land is drained by a number of small rivers which flow some to Lough Mask and some to Lough Corrib.

Eastern Ireland. East of the Shannon basin, numerous rivers flow east to the Irish Sea. The largest is the Boyne, which flows through a country rich in antiquities and historical associations. Round towers and sculptured crosses are numerous. Tara, near Navan, the seat of the ancient kings of Ireland, is famous in song and legend. Drogheda, at the mouth, manufactures linen and exports the agricultural and dairy produce of the eastern plain. The Liffey, also flowing into the Irish Sea, rises in the picturesque Wicklow Mountains to the south. Dublin, the capital, on a magnificent bay, is built at the mouth of the Liffey. The surroundings are remarkably beautiful, and there are some fine streets and buildings. Dublin has important brewing and other industries. Like the capitals of England and Scotland, Dublin is on the east coast, showing how important proximity to Europe has been throughout our island history.

Southern Highlands of Leinster and Munster. South of a line drawn from Galway Bay to Dublin Bay, Ireland is again mountainous. As in the north, lowlands break the mountains up into separate masses, many of which are higher and more extensive than those of Ulster. The lower course of the Shannon lies in the highland region, and has already been described. East of the Slieve Bloom and Silvermine Mountains, which form its eastern margin, is the lowland drained by the Suir-Nore-Barrow. The Barrow—the main river—is formed by streams from the Slieve Bloom and the Bog of Allen, and flows due south between the Wicklow and Wexford Mountains on the east, and the mountains of Kilkenny on the west. The Nore, also from the Slieve Bloom, flows through past Kilkenny, parallel to the Barrow, but separated from it by hilly but good agricultural and grazing country. Anthracite coal is worked near Castlecomer; marble, lead, and other minerals near Kilkenny. The Suir, from the Silvermine Mountains, first flows south, but is turned east by the spurs of the Knockmealdown Mountains, and flows past Clonmel and Carrick between mountains rising to 2600 feet. It enters the Barrow at Waterford, at the head of Watertord harbour, which exports dairy produce and provisions.

East of this lowland are the Wicklow Mountains, with magnificent peak, valley, glen and lake scenery. Of many lovely vales, that of Avoca is the most famous, with Arklow at its mouth. Lead ore is exported from Wicklow. The southern slopes are drained by the Slaney, flowing to Wexford harbour, where Wexford exports agricultural produce; and Rosslare is the port for Fishguard.

West of the Suir-Nore-Barrow lowland, the Slieve Bloom, Silvermine, and Knockmealdown Mountains form a nearly continuous belt of highlands. The rivers no longer run north and south in broad vales, but east and west in long, parallel valleys, which widen into lowlands at the mouths. The Blackwater flows along the northern base of the Boggeragh Mountains past Mallow and Lismore, and turns abruptly south to Youghal Bay, whence Youghal, with salmon fisheries, exports its agricultural and dairy produce. The Lee, coming down from the Kerry Mountains, flows east to Cork harbour, which opens to the south, and the Bandon in a parallel valley flows through similar mountain scenery, turning south-east to Kinsale harbour. Many of the fine natural harbours of southern Ireland are spoilt by bars at their mouths. Cork is one of the finest in the world, and could hold our entire Navy. It contains many islands, on one of which is Queenstown, where Atlantic liners call for mails and passengers. Distilling, brewing, bacon curing, tanning, glovemaking, and some woollen manufactures are carried on at Cork. The export trade in provisions is very large, and shipbuilding is important. Kinsale is a fishing port.

Kerry Mountains and Killarney. The south-west of Ireland consists of lofty and picturesque mountains running westward down to the sea, forming a wild, rocky coast, with many headlands and long, narrow bays. Among the latter, notice Dingle Bay, Kenmare River, Bantry Bay, and Dunmanus Bay. The rivers are short and rapid, and afford excellent fishing. In the north, the mountains are known as Macgillicuddy's Reeks, with Carrantuol, over 3000 feet, the highest mountain in Ireland.

In the midst of those magnificent towering peaks are embosomed the far-famed lakes of Killarney, with many islands, richly wooded like the shores. Much of Kerry is unproductive moorland. As little agriculture is possible, towns are few and population sparse. Round the dangerous coast fishing is important. On Valentia Island is a meteorological station, from which we receive the first warning ot storms approaching from the Atlantic.

Islands in British Waters. The Isle of Man. The Isle of Man rises in the Irish Sea, midway between Strangford Lough and St. Bee's Head in Cumberland, each less than 30 miles distant, while the Scottish coast is considerably nearer. The island is 33 miles long and 12 miles wide. The centre and south parts of the island are mountainous, with lovely glens opening to the sea. Snaefell, 2000 feet high, is the highest point, and commands a fine view of the island and of the coasts of England, Scotland, and Ireland. Minerals are abundant, especially lead. Farming is extremely good; all round the coast fishing is important, and most of the towns—of which Douglas, Ramsey, and Peel are the largest—are situated there. The tourist traffic is immense in summer, when the island becomes the playground of Lancashire. Man preserves the right of self-government, a separate Parliament, known as the House of Keys, separate judges, or deemsters, and many relics of a long and interesting history.

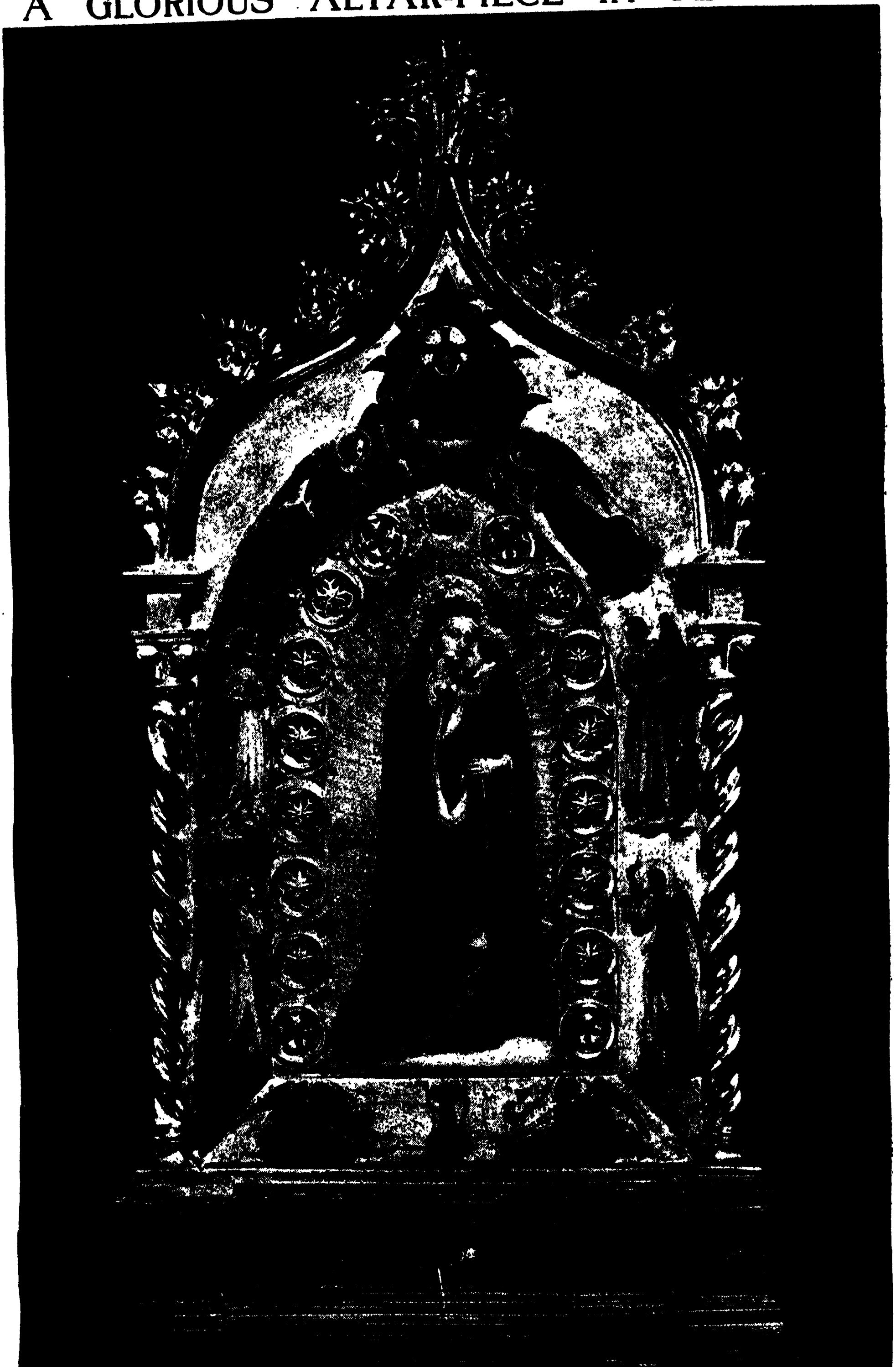
The Channel Islands. These, the last shreds of our once great French possessions, are 80 miles from our own shores, and within 10 of the French coast. The largest are Jersey (45 sq. miles), Guernsey (25 sq. miles), and Alderney (4 sq. miles). Sark has an area of barely two square miles. Both population and language are of French origin, and the islands have Home Rule. The coast scenery is wild and imposing, and the surrounding seas are strewed with sunken rocks, and rendered still more dangerous by strong currents. In all, the growing of early fruit and vegetables is important, and fine breeds of dairy cattle are grazed on the sunny meadows.

Jersey and Guernsey are kept in touch with England by a regular steamer service from Southampton and Weymouth. The islands are also served by steamers from several French ports. Occasionally communication by sea is dislocated owing to severe weather in the English Channel, but this inconvenience to business has been largely overcome by the aid of a wireless telegraphy installation, which enables fruit-growers and other business men to make their bargains with the outside world.

The capital and port of Jersey is St. Helier, and that of Guernsey is St. Peter Port.

A. J. AND F. D. HERBERTSON

A GLORIOUS ALTAR-PIECE IN FLORENCE



THE MADONNA IN THIS SHRINE WAS PAINTED BY FRA ANGELICO AND IS NOW IN THE MUSEUM OF SAN MARCO, FLORENCE

The Triumph of Naturalism in Gothic Craftsmanship, and the Growth of Expression in Plastic Art.

THE DAWN OF THE RENAISSANCE

WE have dealt exclusively with the structural principles of Gothic architecture and the far-reaching changes brought about by the general adoption of the pointed arch. It is only natural that the sister arts of sculpture and painting, which were then completely in the service of, and subordinated to, architecture, should have had to undergo corresponding modifications. With the reduction of solid masonry to a minimum, the demand for extensive wall-paintings had practically ceased to exist. Their place in the new order of things was taken by huge stained-glass windows, and the painters had to express themselves in small panel-pictures for altar-pieces, which could no longer be monumental in character, but forced the artists from hierarchic dignity and lifelessness to the search for human emotions and movement. This signified the inauguration of a return from the traditional convention to the study of Nature.

In sculpture, even more than in painting, naturalism triumphed over formalism. Romanesque sculpture had been derived entirely from Roman and Byzantine sources. It was impressive at times and dignified, and well suited to the architecture by which it was set off. But the Gothic style of building, with its upward tendency and graceful slenderness, necessitated a different treatment of the human figure, which, in the hands of the mediæval sculptor, became more flexible, slender, elegant, and expressive—in short, more human. As in the preceding epoch, the representation of the nude remained beyond the pale of art, but, nevertheless, the form of the limbs was better understood, and the drapery treated in gently flowing lines and ample folds. At the same time the features lost their stony impassiveness, in the place of which we find serenity and even emotional expression.

More marked even than in sculpture, properly speaking, is the naturalistic tendency in Gothic stone carving, where the forms of the local flora are repeated with astounding faithfulness, and with an appreciation of the beauty of Nature's handicraft that has never been equalled at any other period. Some of the Gothic cathedrals present in the stone carvings of the capitals, porches, and niches a perfect course of natural history—an encyclopædia of the knowledge of the time, comprising Scriptural history, legend, contemporary life in all its phases, the sciences and trades and crafts, animal and plant forms, allegorical representations of the forces and phenomena of Nature, and many other themes.

This style of decoration applies with particular force to the cathedrals of France; but even in Italy, where the alien Gothic style never became properly naturalised, we find a similar intention in the decorative adjuncts to architecture. Thus the relief panels of the Florence Campanile deal with the creation of Adam and Eve; "Jabal—the father of such as have cattle;" "Jubal—the father of all who handle harps and organ;" Tubal Cain, the metal-worker; Noah, the vine-grower; astronomy, arithmetic, geometry, grammar, logic, rhetoric, music, building, pottery, wool-weaving, law, the three elements personified by a horseman, Dædalus, and a ship with its crew; ploughing, transport, painting, and sculpture. This Campanile has not inaptly been called a "Gospel of Intelligent Labour."

The Gothic craftsmen of France and Germany attained great skill in the polychromatic treatment of stone carving, and more particularly of figures and reliefs carved in wood, for altars and church decoration in general. That a period with a distinct leaning towards realism should not have neglected portraiture is only natural. The beginnings of Gothic portrait sculpture must be searched for in the cathedrals, among the tomb slabs showing the figure of the dead carved in low relief. Then came the recumbent figure modelled in the round, and finally the kneeling figure in the attitude of prayer, in all of which the sculptors endeavoured to reproduce as faithfully as possible the actual features of those who had passed away.

Ivory carving, too, was widely practised during the Gothic period, and no doubt exercised a great influence on the plastic art of that time. The shape of the tusk necessitated the adaptation of the pose of the figure to the curve. Perhaps the more flowing line and increased movement of Gothic sculpture, as compared to Romanesque, may to a certain extent be due to the artist's endeavour to fit his figure into a given shape, or indirectly to the accidental form of the elephant's tusk.* It is, at any rate, undeniable that many of the statues carved in stone or wood during the fifteenth century follow the swinging line of the ivory's natural growth.

Italian Gothic Art. In Italy, painting and sculpture had never lost their independent existence as completely as in the North, where the Gothic architectural system exercised tyrannical sway over the sister arts. The smouldering fire that burnt under the cold Byzantine tradition broke forth in brilliant flame in the middle of the thirteenth century in the person of Niccola Pisano, the creator of the famous pulpit in Pisa, who, inspired by the antique, revived for a short time the noble grandeur of classic form. But Niccola was an isolated phenomenon, and his son, Giovanni, abandoning the direction indicated by his father, succumbed to the influence of the Northern Gothic, and gave his compositions dramatic intensity and emotional life in the place of antique impassiveness. His masterpiece is the pulpit of St. Andrea at Pistoia.

A STATUE OF THE FOURTEENTH CENTURY, FLORENCE

While plastic art thus received a new impulse from Pisa, Florence and Siena were the centres where painting first broke the fetters of Byzantine formalism and achieved individual freedom. Cimabue, a thirteenth-century Florentine, has for centuries been held to be the father of modern painting, and the teacher of Giotto. Modern research has, however, deprived him of many of the existing works that had been placed to his credit. Cimabue was a mosaic worker—an excellent artist, who infused life into the stiff manner of his precursors, but he was not the epoch-making reformer of Vasari's pretty tale.

The "First Modern Painter." Whether Giotto was actually a pupil of Cimabue or no, one thing is certain: that his art has far more in common with that of the sculptor Giovanni Pisano than with that of his supposed master. Giotto (1266-1337) may be called the first modern painter. He was the first to paint objects and figures in a manner to make us realise without mental effort the plastic reality of his painted subject. Measured by the modern standard, his drawing is faulty, the figures clumsy and heavy, the perspective wrong; but his was the first step toward freedom of composition, dramatic life and movement, toward the realisation of an artistic ideal beyond the merely formal beauty of harmoniously arranged line and colour. To appreciate his work fully, one has to study his glorious frescoes in the Arena Chapel in Padua, at St. Croce in Florence, and at St. Francis in Assisi. Like most of the early Italian masters, Giotto was well versed in many arts. His combined achievement as architect and sculptor can be admired in the Florence Campanile.

In his painting, as in his sculpture, he, like all the leaders in art, drew his inspiration direct from Nature. And like all those who turn away from Nature to imitate consciously the work of a master, the followers of Giotto—the "Giottesques"—lost sight of the real significance of things, copied the weaknesses and the mere outer form of the admired models without grasping the spirit, and delayed the progress of painting by a full half-century. Giotto the painter had logically transferred to another sphere, and developed the principles underlying the work of the sculptor Giovanni Pisano. It was a sculptor, Andrea Pisano, who was Giotto's legitimate successor; and while painting was under a temporary eclipse, Andrea and his pupils infused vigorous life into the art of relief sculpture. With the seriousness and sincerity of Giotto, and with that master's disregard of conventional form, he combines an increased sense of pure beauty. His bronze gates of the Florence baptistery represent his work at his best period.

The greatest of the "Giottesques" is Andrea del Cione, called Orcagna, Andrea Pisano's pupil, and equally famed as painter, sculptor, goldsmith, and architect. The Loggia de' Lanzi in Florence is said to be built from his plans; the solemn, splendid fresco of the Last Judgment in S. Maria Novella, and the richly sculptured Gothic tabernacle at Or San Michele in Florence, are wrought by his hand, though the famous, naïvely realistic "Triumph of Death" fresco at the Campo Santo in Pisa, which was formerly attributed to his brush, is now held to be the work of the Sienese Lorenzetti.

What Cimabue was believed to have done for painting in Florence, Duccio di Buoninsegna certainly did for Siena. He, too, broke away from Byzantium, gave life to his figures, suggested the human form under the nobly arranged [illegible] of the

character and emotion to each figure. [illegible] successors, among whom Simone Martini, Taddeo Gaddi, and the Lorenzetti were the most prominent, continued in the same direction. The

THE MASTERPIECE OF GIOVANNI PISANO

ONE OF THE PANELS FROM PISANO'S PULPIT, SHOWING THE NATIVITY

THE FAMOUS PULPIT BY GIOVANNI PISANO AT PISTOIA, AND A DETAIL FROM IT

Sienese were ever more concerned with expressing the inner life of the soul than the physical life of the body. It was a natural consequence that they excelled more in the small panel picture than in the large fresco. The Sienese School did not have the vitality of the School of Florence, and fell into decay when the art of the rival city achieved its greatest triumphs.

A Great Florentine Painter. Fra Giovanni Angelico da Fiesole (1387-1455), a Dominican monk, is the last great Florentine painter of the Gothic period, and the first of the Early Renaissance. In his art, pure, spiritual, ardent, and sincere, he proves himself a follower of Giotto in the dramatic conception of the subjects and in the freedom of his grouping, while the soulful, emotional depth of his sentiment and the celestial beauty and purity of expression are derived from Sienese sources. He is the most lovable painter of all times, the painter of heavenly bliss, of pure Christianity, of angelic beauty. The spirituality and saintliness of his art are so striking, and have been lain so much stress on, that many critics have overlooked another and scarcely less important side of his character—his systematic study of the antique, of the human form, and of Nature in general. He was the first painter who represented the Christ-child entirely naked, and drew the nude forms, not from imagination, but from the living model; the first Italian who painted an actual landscape from Nature; one of the first to study aerial perspective, to introduce actual portraiture into his frescoes, and classical forms into his architectural backgrounds. For all these reasons Fra Angelico must be accorded a position, and no mean position, among the painters of the Italian Renaissance. To appreciate Fra Angelico's position in the art of his time, it is necessary to study his wonderful frescoes in the cells of S. Marco in Florence and in the chapel of Nicholas V. in the Vatican.

PAINTING OF THE MADONNA AND CHILD ATTRIBUTED TO CIMABUE

The Renaissance. The great movement in art and letters known as the Renaissance had its beginning in Italy in the early part of the fifteenth century. In the Gothic period art had been almost entirely at the service of the Church. Fostered by the spread of humanism, which, under the rule of the Medici family in Florence, led to the establishment of a Platonic Academy, the dormant love of the Italians for the forms of classic art, which are so closely connected with paganism, was given a new powerful impetus. Scientists and men of letters, architects, painters, and sculptors, devoted themselves to the study of classic literature and antique art. The writings of Greek and Roman poets and philosophers were popularised, the fragments of antique sculpture unearthed, the ruins of classic buildings investigated, and the lessons derived from them applied to the creation of new monumental buildings. At the same time, art became to a great extent secularised, and its patronage passed from the Church to the Courts of the Princes, and to the wealthy citizens. In the North, the Reformation coincides with the Renaissance, and even in Italy new fields were opened to architects, painters, and sculptors.

Nothing could be more erroneous than to think that the principles of Renaissance architecture were a mere repetition of the rediscovered classic forms. The style is based on the revival of the classic orders, but these are applied in an entirely new manner, suitable to the modern requirements. As Professor Banister Fletcher has tersely put it, "Architecture ceased to a certain extent to be subject to the considerations of use, becoming largely independent of constructive exigencies, and to a greater extent an art of free expression in which beauty of design was sought for. Speaking generally, there was an endeavour to reconcile the Gothic and the Roman method of construction—that is, the body and the dress were the same thing constructively, because the architects of the period, attracted by the mere external appearance of ancient Roman art, but perceiving that this form was merely an envelope, continued in the matter of construction to a large extent to follow the traditions of the Middle Ages, which did not separate the structure from the decoration."

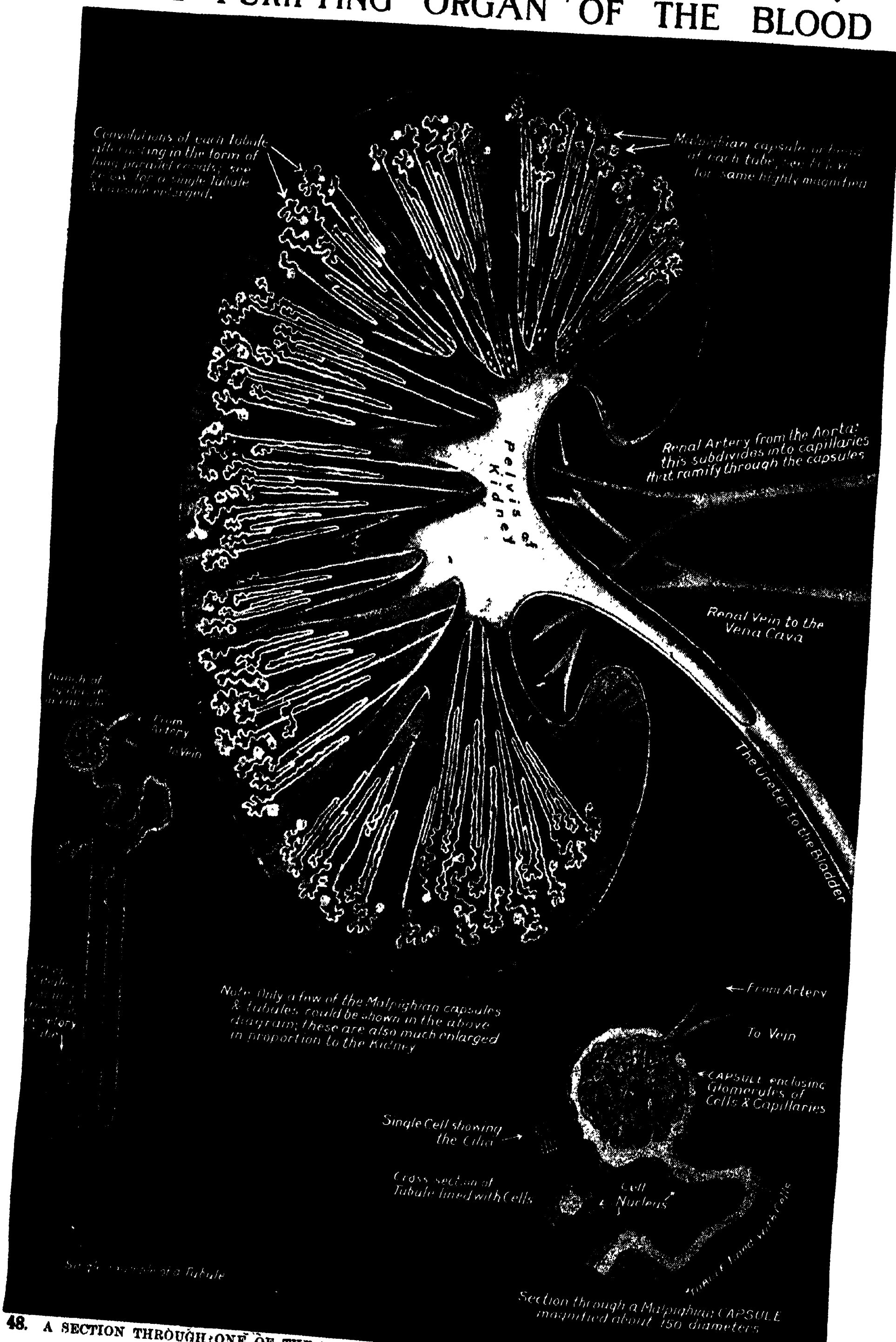
P. G. KONODY

PAINTINGS BY FRA ANGELICO AND GIOTTO

ST. STEPHEN DISTRIBUTING ALMS—FROM THE PAINTING BY ANGELICO AT THE VATICAN

THE MARRIAGE AT CANA—FROM THE PAINTING BY GIOTTO AT PADUA

THE PURIFYING ORGAN OF THE BLOOD.



48. A SECTION THROUGH ONE OF THE KIDNEYS, THE MARVELLOUS MECHANISM THAT RIDS THE BODY OF ITS WASTE PRODUCTS, WHICH WOULD OTHERWISE POISON THE HUMAN SYSTEM.

Growth of the Hair and Nails. The False and the True Skins. Common Sensations. The Pores. The Work of the Kidneys.

THE SKIN AND ITS USES

We have now to describe the structure and the function of the skin; the care of it is dealt with in the section on HEALTH.

The skin [49] consists of two layers, the inner one called the *dermis* or *cutis vera*, which contains all the nerves of touch and feeling and all the blood-vessels; and the outer one, the *epidermis*, or false skin, so-called because it is over the true skin. It is thin, and contains no nerves or blood, so that when we prick it lightly, as in the finger when sewing with a needle, there is no pain and no blood.

The hair and nails are really hardened parts of this outer layer of the skin. A short description of these will show how wonderfully even the epidermis is made. Being only the outer skin, it would seem that it could not contain anything very interesting. We will therefore begin with the *hair* and the *nails*, the structure of which is indeed remarkable.

The Hair. The surface of a hair is, as it were, thatched with cells overlying each other like tiles, while the centre is not hollow, but filled with a sort of pith. Straight hairs are round, while wavy and curly hair is oval; black is the coarsest, and flaxen the finest. Hairs do not grow straight out of the skin, but at an angle, so that they can be made to lie down flat. In the head they generally all radiate from one centre, and number about 100,000. It is calculated that four sound hairs will support a pound weight. The whole body is covered with them, though they vary greatly in length and quality. Those of animals serve, of course, for the purposes of clothing; in man, they are for the most part an ornament.

How Hair Grows. Each hair grows out of a deep pit in the skin, that descends right through both false and true skins into the underlying layer of fat. This pit is lined throughout with the cells of the epidermis, or false skin, just as if the pit had been made by pushing in the skin. These tile-like cells that line the sides of the hair-pit point downward, while the tile-like cells covering the hair point upward, the one thus locking into the other, and preventing the hair from being easily pulled out. When, however, it is drawn out, it generally brings away the sides of the growing pit with it.

At the base of this pit is a small pimple, or bulb, made of the same epidermal cells. Just as the outer layers of this are about to die, they form a horny substance, as we shall see they do in the skin, but of a very superior nature. The outermost dead layer of cells, instead of lying about anyhow ready to be brushed off, as it does on the skin, has the cells arranged, as we have seen, like tiles. The growth from below is fairly rapid, and, as no cells fall off above, the young hair is soon pushed up out of the pit, which it exactly fills, and goes on increasing in length until the growing bulb at the base is exhausted, when it finally falls off. Just as the hair leaves the skin a tube opens on each side of the "root," or hair-pit, up which is discharged a natural pomade for the hair. Attached, too, to the bulb on the under side of the hair, and passing upward to the skin, is a small band of muscle, which, by contraction, has the power of erecting the hair, so that it stands up or bristles when the person is agitated, as with fear.

The Nails. The nails [52] are beautifully modified outgrowths of the horny substance of the skin, and are of great use in giving firmness to the finger-tips and in grasping small objects. They grow in a peculiar manner, for at the base of a nail the outer skin is folded inward into a deep trench, from the bottom of which these horny cells of the epidermis grow up in the same way as in a hair—this time, however, in the flat shape of the trench, instead of the round shape of the hair-pit. The nails are free from all pigment.

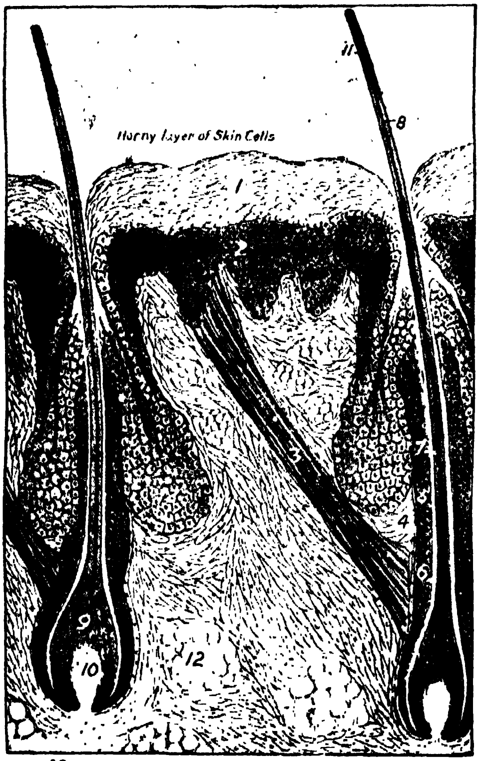
The true skin which forms the bed of the nail is in ridges and furrows like a ploughed field, and the horny nail as it is pushed up from below often shows corresponding ridges.

The Epidermis. The false skin itself merits a short special description, if only to show the true interest and romance that pervade the story of the simplest and least complex of the body structures.

In the first place, the epidermis, like the rest of the body, is alive—that is, all but the outside of it. In the next, it is composed of from a dozen to twenty or more layers of living cells, packed side by side and layer on layer, just like the bricks in a wall. Each of these cells—like every other cell in the body—not only is born, grows, matures, ages, and dies, but eats, drinks, breathes, frequently moves, and certainly works, not only doing its share in supporting the general structure, but aiding in some special way.

The History of a Skin Cell. The life-history of one of these cells is interesting. Born by the parent cell squeezing off part of its own body, it begins an independent life, the young cell forming one of a row of similar ones in the deepest layer of this outer skin, and next to the true one. Here the young cells are placed by the side of a small blood-vessel, which supplies them regularly with fresh air and their share of food. After a time they become parents themselves by squeezing off part of their own bodies in their turn, and these new cells now lie next the blood-vessel, their parents mounting a row higher and nearer the surface. The parents have now to depend for all their

nourishment on their offspring next the blood-stream, who pass on what they can spare. Soon the parents become grandparents, then great-grandparents, and being further removed from the blood-vessel—their only source of food—they get less and less of it, and as a natural consequence become smaller and smaller. Just before they die of starvation, however, the layer of cells next the surface sets to work once more, and manufactures a peculiar horny substance called *keratin*, or horn—partly, it is suspected, out of their own bodies. This gives firmness to the surface of the skin and to the outside of the



49. VERTICAL SECTION OF HUMAN SKIN

1. Epidermis, or false skin. 2 Corium, or true skin. 3. Muscles of hair follicles. 4 Hair follicles. 5. Outer root sheath. 6. Inner root sheath. 7. Fibrous substance of hair. 8. Medulla of hair. 9. Hair bulb. 10. Papillæ of hair bulb. 11. Sahft of hair. 12 Layer of adipose tissue (fat cells).

hair; then, reaching the surface, the particles of keratin lie in countless thousands in fine dust, which can be shaken out in clouds at night from one's garments, and scraped or brushed off the skin. Such, in bold outlines, is the story of one of the most insignificant structures of the body.

The Dermis. Coming now to the *cutis vera*, the derma or true skin, we observe that it differs in every way from the epidermis. It is arranged in ridges and furrows in many places, the folds of which the epidermis follows. The ridges are covered by double rows of papillæ, which are small projections connected with the organ of touch. There are also everywhere sensory nerves connected with the ordinary sensations and pain, small tubes connected with the openings on the surface called pores, innumerable networks of capillaries and lymphatics, and little glands that oil the hair. There is also a quantity of elastic tissue which enables the true skin to stretch, and the whole of it lies on a layer of fat [50], varying from ¼ in. to 3 in. in thickness.

We will consider these structures and their uses in the order in which we have named them.

The Organs of Touch. The first are the organs of the sense of touch. This sense is principally connected with those ridges where, in double rows, are the elevations called papillæ, or pimples [50], of which we have spoken. Over other parts of the skin the papillæ are more or less thinly scattered, but nowhere so regularly arranged as in the hand and foot; they are about one hundredth of an inch long. Each papilla is a perfect network of blood-vessels, and most of them contain an oval body—sometimes like a small silk cocoon—consisting of nerve fibres closely wound round each other. There are also, in some cases, little bulbs on the nerve fibres like small oranges. Although they are organs of touch, yet these papillæ are never allowed to come in contact with the object touched. They are all covered over with the epidermis, or scarf-skin, which is only thinly spread over the papillæ, but is thicker between them, so that the papillæ are isolated by it; and it is easier to tell which one is touched.

Unless the papillæ were covered with the epidermis, the sense of touch would be lost. All feeling of *touch* is in the skin, but in very different degrees in the various parts of the body; for instance, if the skin on the back is touched at the same time with the two legs of a pair of compasses two inches apart, only *one* touch is felt; whereas on the tongue or fingers, however little the points are separated, *two* touches are felt. If a small portion of the skin be scraped off, and the raw surface be touched, pain is felt, but there is no sense of touch.

The tips of the fingers and the tongue have the finest sense of touch, which, however, may be lost if the object touching them be very cold or very hot. This delicate faculty of touch is the sentry of the body, giving immediate warning of the character of the substance with which the body is brought into contact.

Sensation of Touch. We may now consider certain sensations of touch and pressure. The whiskers of cats, the antennæ or "feelers" of insects, the wings of bats, the trunks of elephants, the hands of man, are all instruments of touch. They acquaint their owners with the size, form, and other characteristics of bodies. Touching is as different from mere feeling as listening and looking are from mere hearing and seeing. This sense, however, often leads us astray if not corrected by other faculties, such as eyesight. The cavity in a tooth felt by the tongue is always imagined to be much larger than it is.

Curious illusions exist with regard to *touch*. If the eyes are closed and the first and middle fingers crossed, and a small pea or bead placed between them, two peas or beads are felt. This is caused by two parts of the fingers

being enabled to touch the same small object, which they could not do unless they were crossed, so the mind wrongly concludes that there are two objects. At first, touch is not localised by the brain—only felt. An infant pricked by a pin only cries, but does not avoid the injury, because it does not know where it is. As it

50. SECTION OF SKIN SHOWING (†) TOUCH PAPILLÆ

grows older, a map, as it were, of the body is formed in the brain, enabling it to tell at once the point touched.

A finger can discern blindfold whether it is touching silk, velvet, cotton, flannel, wood, iron, or stone; but if the outer skin be cut off and the under skin left raw, only pain is felt when any object is touched.

The accuracy of the sense of touch depends, as we have seen, on the nearness together and sensitiveness of the papillæ. The differences in various parts of the body are as follow. Two sensations are produced by the points of a compass at the following distances: Tip of tongue, 1-24th in. apart; tip of forefinger, 1-12th in. apart; nose, $\frac{1}{4}$in. apart; palm of hand, $\frac{1}{2}$ in. apart; back of hand, 1 in. apart; arm or leg, $1\frac{1}{2}$ in. apart; back of neck, 2 in. apart; thigh, $2\frac{1}{2}$ in. apart; and back, 3 in. apart.

Sensation of Pressure. *Pressure* is a different sensation from mere touch. A card on the back of the hand touches it, but a leaden weight presses it.

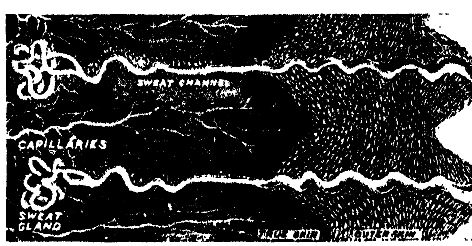
The judgment of weight is based on the amount of pressure and of muscular effort needed to raise it. By lifting a weight it was found that a man could distinguish $19\frac{1}{2}$ oz. from 20 oz.; while by the mere difference of pressure in laying the weight on the hand, he could only distinguish $14\frac{1}{2}$ oz. from 15 oz. The combination of the two results gives the most accurate statement.

Common Sensation. Under the head of common sensation are included the sense of temperature, pain, pleasure, itching, and tickling. This sensation does not depend upon the touch corpuscles merely, but upon the sensory nerves in the skin. This fact is important; for instance, the sense of touch does not depend on the thinness of the epidermis, but upon the number of touch corpuscules, and is hence most acute at the tips of the fingers. Sensation, on the other hand, depends directly on the thinness of the epidermis, and is most acute on the back of the hand and cheek.

Common sensation is a great protection of the whole body, for just as the wall is the defence of a fortified town, and when that is passed the town is taken, so is the skin the vital fortification of the body, to which it is such a powerful defence that when it is gone to a great extent the life goes too. The nerves under the skin are like the coastguards round our coasts, and give immediate warning to the central government when any enemy begins to attack the body.

Sensation of Heat and Cold. The sensation of heat and cold is, again, quite different from that of mere touch, and depends on the thinness of the skin. This sensation is often very fallacious. If one hand be placed in cold water and the other in very hot water, and then both hands be placed in warm water, this will seem hot to one hand and cold to the other. In fever, again, we feel excessively cold when shivering, and yet are in a burning heat; while, when we perspire, we feel much hotter and yet are really cooler. People feel warmer after drinking spirits, and yet the temperature of the body is always lowered.

Sensation of Pain. Pain is a most valuable sensation, for it generally calls our attention to some injury or disease. It is difficult to tell where mere feeling passes into pain, but usually it is when any sensation becomes injurious to the body. Heat is enjoyable up to a certain point; then, as in the case of cold, it becomes pain, which can also be easily excited *by mere ideas of sensation in the mind. In fact, most sensations can be produced by ideas.* Tickling may be pleasurable or



51. THE SWEAT-GLANDS OF THE SKIN

painful, according to its intensity, and can be produced with the greatest effect in the soles of the feet.

The Pores. Respiration and transpiration are other functions of the skin, and are carried on largely by means of the pores [**51**]. These are glandular structures connected with the skin, and concerning which the vaguest ideas are current. Some imagine them to be little holes in which the hairs are inserted; others, again, believe they are holes through the skin, opening into the body, through which

the perspiration comes, the skin being thus a sort of sieve. Both these ideas are wrong. There are no holes in any part of the skin leading inside the body. The real "pore" is a tiny opening, guarded by lips, at the end of a short tube which has no opening internally at all, but is coiled up at the end like a watch-spring. These pores *breathe out* about 400 grains of carbonic acid gas, besides about a pint of water a day. They are very numerous, and exist all over the body, though they are most numerous where most perspiration occurs, especially on the palms of the hands and the soles of the feet. It is of the utmost importance for health that the mouths of these glands or pores should be kept open, and free from all obstruction, for in all there are no less than twenty-eight miles of them.

By means of the pores, and also directly through its surface, the skin in this way does 1-150th part of the work of the lungs as regards inspiration of oxygen, but about 1-30th as regards expiration of CO_2. This can be shown as follows: If a hand be held in a closed lantern for two hours and then a candle be inserted, the latter will go out, because of the amount of CO_2 in the air. The skin not only gives off CO_2, but other poisonous matters.

Hence it is that burns and scalds are more serious in proportion to their extent of surface than to their depth—it being less serious to lose a certain amount of flesh, and even of bone, than a large amount of skin. In injuries, too, especially about the hand and fingers, when they are maimed or crushed, the important point that decides whether it is better to remove or to leave the injured parts is the amount of skin by which they remain attached, for on this the life of the part depends.

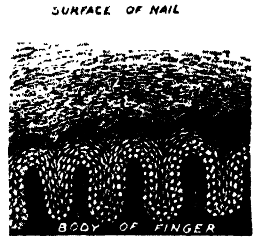
Amount of Water Given Off. But in addition to respiration, the pores excrete, as we have seen, a large amount of water. As a rule, this evaporates from the surface of the body all day long, and is called *transpiration.* When, however, the amount is so great that it cannot be carried off, but remains as drops on the surface, it is called *perspiration*, or sweat, which has the following composition: Water, 99·5; acids, ·1; salts, ·1; fats, ·1; other bodies, ·2. Total, 100·0.

Two pounds of it are given off daily—twice as much fluid as comes from the lungs; 1-67th of the whole body weight is thus lost daily. The pores, or sweat-glands, are most numerous and largest on the palms, the soles, the forehead, and the sides of the nose; there are few on the back and neck, and none on the lips. In the palms there are 3000 to the square inch; on the neck, 400. There are in all two and a half millions, and they present a surface of 3000 square inches.

Perspiration is increased by heat, watery blood, exercise, drugs, nerve action, and diseases, such as consumption and rheumatic fever. It is decreased by cold, excessive urination, rest, drugs, and nerve action. The sweat-centre and that for dilating the skin blood-vessels generally act together, but there may be "cold sweat" with pallor and little blood.

Regulation of Heat. Owing to the innumerable blood capillaries just under the surface, the skin is also the heat regulator of the body, and acts like the balance of a watch, or the governor-balls of a steam-engine. When this power is lost the person dies, as in one or two cases where the skin has been varnished all over.

If the external air be cold, the skin contracts and tightly closes all the little blood-vessels, thus preserving the heat of the precious fluid by keeping it from the surface; while, on the other hand, if the weather be hot, it allows the blood-vessels to expand, and, by bringing the blood to the surface, controls the heat of the body by radiation and evaporation. This power is temporarily paralysed by certain drugs, notably by alcohol.



52. SECTION THROUGH FINGER-NAIL

Other Uses of Skin. Then, again the skin is a secreting organ. It produces a peculiar oil for the hair, not only in the head, but all over the body. This oil is made under the skin in little vessels called sebaceous glands, which open by a small tube on each side of the thousands of tiny hairs with which the skin is covered.

But the skin has many additional uses. It is the beginning and the end of all the *beauty* of the body, which literally is but skin-deep. Whatever strength may be in muscle, there is no beauty in its bare appearance. Whatever loveliness exists in the rosy cheek, the white forehead, the well-rounded arm, or the graceful figure—all these vanish with the skin. A skinned rabbit has no beauty.

Here we reach the third of the great excretory organs of the body (in addition to the bowels), which are the lungs, the skin, and the kidneys. The lungs specially excrete the gas CO_2; the skin, the *liquid*, water; and the kidneys (in addition to the water), the *solid*, urea. These are all true excretions, and the three organs are therefore specially associated together, as three men might be, labouring at one piece of work. If any one of the three is partially or wholly disabled it throws more mork upon the other two. In consumption, for instance, if a large part of the lung is destroyed, the skin and kidneys have to do the work. With a dirty skin more work is thrown on the lungs and kidneys, while in diseased kidneys the skin has to be very active.

The Kidneys and Their Structure. The kidneys are two bodies shaped like beans, situated at the inner side of the lower ribs, close beside the spine [48], the right being the lower of the two. Each one is 4 in. long, 2½ in. broad, and 1 in. thick, and weighs 4½ ounces.

From each kidney a tube like a small india-rubber pipe, called a *ureter*, from 12 to 16 in.

long, leads down to the bladder, which is a single central organ like a bag, containing the excretion of the kidneys, called urine. From this bladder a short tube called the *urethra* enables the urine to be excreted. The construction of the kidneys is as follows: Each is covered with a fibrous skin called a *capsule*. Inside this the substance of the kidney divides itself into three—the outer part, or *cortex*, which is deep red; the *medullary*, which is paler; and the innermost hollow part, called the *pelvis*. The first is one-third of the thickness of the kidney, the second one-half.

The kidney, itself, is a compound tubular gland, and the medullary part is almost exclusively composed of tubes. These ascend into the cortex at intervals and terminate in dilated extremities called Malpighian corpuscles; or, rather, the tubes may be said to start here, and, after pursuing a very devious course for some 2 in., terminate and discharge their contents from tiny orifices in each of the 12 pyramids which project from the medullary part into the pelvis, where all the urine thus discharged collects and eventually leaves the kidney from the hilum by the ureter. There are 30 to 40 orifices in each pyramid that discharge urine, and the number of corpuscles whence it is obtained from the blood are estimated at about half a million in each kidney.

Each Malpighian corpuscle shows a deep, cup-shaped depression that embraces a little tuft of capillary blood-vessels like a raspberry, the whole being one-125th in. in diameter.

Their Blood Supply. The blood-supply of the kidney is peculiar. It arrives by the renal artery direct from the aorta; the arteries form regular arches at the junction of the cortical and medullary portions in the substance of the kidney. From these arches branches ascend into the cortex of the kidney, having at each side those expanded tufts of blood-vessels which form the Malpighian corpuscles. The artery suddenly breaks up into this cluster of capillaries, and seems to have pushed before it the dilated end of the urinary tubule, so that two layers of it become wrapped round the blood-vessels, leaving just room for the two vessels that form the stalk.

The Work of the Kidneys. The blood, purified in the lungs of its carbonic acid gas, comes straight to the kidney after leaving the heart, and having first had water abstracted from it in the Malpighian corpuscles, has urea and other substances extracted from it in another part of the urinary tubules. It must be remembered that the tubule, originating in the Malpighian corpuscles, pursues a very devious course, during which it is closely surrounded by blood-vessels, from which, it is believed, by the vital action of the urinary cells, the various substances are extracted.

The blood, thus purified, returns by the renal veins to the inferior vena cava; and differs totally from all other venous blood in being bright red, and actually *the purest blood in the body*. It must be remembered one artery carries venous blood, the pulmonary, and two veins carry arterial blood, the pulmonary and the renal. All the tubules uniting pour their contents into the pelvis of the kidney, and the fluid is known as urine.

Urine. Urine is a transparent, acid, amber fluid, and is heavier than water, its sp. gr. being about 1020 as compared with 1000. About three pints are produced each day. The following is its chemical composition and daily amount: Water, 52 oz.; urea, 500 grs.; uric acid, 8 grs.; salts, 400 grs.; extractives, 153 grs. The normal colour varies through every shade of yellow and orange. In disease it may be brown or black or green.

The urine is acid in health, and becomes more so when certain acids are taken, also after prolonged exertion or consumption of much animal food. It becomes less acid or alkaline when alkalies are present, and after taking much vegetable food.

Weight and Quantity. Its weight compared with water varies considerably; much drinking may temporarily lower it to 1002, while taking no fluid, and profuse perspiration, may raise it to 1040. Some diseases increase and others lower its specific gravity.

The quantity of urine varies greatly. It is decreased by sweating, by eating dry food, by bleeding, and in some diseases. It is increased by cold, by dry skin, by the use of drugs, by sugar in the urine, by nervous excitability, and in some diseases.

Urea is the principal constituent of the urine, and represents the nitrogenous refuse of the body. It forms half of all the solids in the urine. It is a compound of water, carbonic acid, and nitrogen. As a rule, 500 grains a day are passed, and the amount of nitrogen passed is in proportion to the amount taken in the food. It is not increased by muscular exercise, as was formerly supposed, nor by the amount of the urine, but by animal food and wasting diseases. Urea forms one-10000th part of the blood and one-2000th part of the lymph.

Uric acid is a similar nitrogenous product, but differs in one most important particular; for while urea is soluble, and thus gives no trouble in the system, uric acid is insoluble, and is the source of many bodily ailments, notably gout. In the urine it appears as a brick-red powder.

It is probable that urea and uric acid are not formed in the kidney as bile is formed in the liver, but in the blood, and are only eliminated by the kidneys. If the supply of bile from the liver be stopped, none is made; but if the kidneys do not act, an increased amount of urea is found in the blood. The secretion of urea and the amount of sweat are in inverse proportion, showing the close connection between the kidneys and the skin.

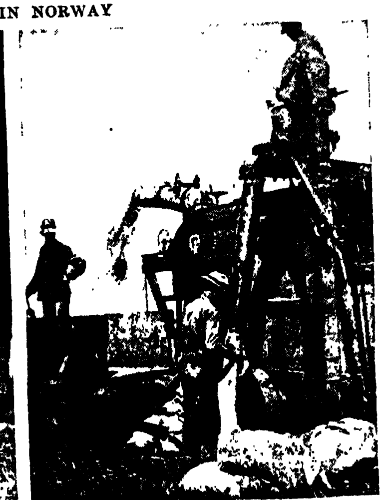
The ureter, about 15 in. long, is a strong tube of four coats, one muscular; it conveys the urine to the bladder by peristalsis, or circular contraction of the muscles, by gravity, and by the *vis a tergo*, or pressure from behind. It enters the bladder by a valve through which the urine trickles drop by drop. The bladder has four coats and many elastic fibres, which keep it in a state of moderate contraction. It holds about a pint, and can be emptied at will.

A. T. SCHOFIELD

THE MODERN IMPLEMENTS OF THE FARM

A SIX-ROWED HOE DRAWN BY AN OX IN NORWAY

AN ELECTRICALLY DRIVEN CHAFF-CUTTER



SACKING WHEAT FROM A THRESHER

AN AUTOMOBILE HOE AT WORK IN A FIELD OF YOUNG BEETROOTS

The Necessity for Up-to-date Implements. The Self-binder and Reaper. The Plough. The Smaller Tools.

MACHINERY OF THE FARM

In the management of a farm perfect equipment is half the battle. Nevertheless, it is probable that on the majority of British farms the implements and machines employed are of old type, involving slow and inefficient work. The great feature of today is to save manual labour, and thus to minimise its cost.

How to Purchase Equipment. Farmers with capital are prone to pride themselves on a smart outfit, new and brightly painted carts and waggons, costly harness, abundantly furnished in brass, with tools and tackle all of the best. Money is well spent if it is spent judiciously in buying not only the best but no more than is required. A man with experience, however, is able to obtain many useful implements and machines as he needs them by attending farm sales, but the amateur or the non-expert, before attempting this method of purchase, should ascertain the market price of his various requirements, and, above all, which are the most substantial and useful. From time to time new implements are introduced by manufacturers, many of which are of great merit. For this reason the best agricultural shows should be attended at least once a year—the Royal, and, let us suggest, the exhibition of the county in which the farmer resides.

Before making a purchase, however, it is well, where the same class of implement or tool is made by various firms, to compare them as far as possible on the show-ground in order to learn their relative price, strength, and capacity for work. Farm tackle bears a good discount, and the buyer should not forget this point, whether in dealing direct with the maker or his agent. As far as possible, implements should be manufactured of wrought iron or steel, and wood —where wood is employed—of the toughest kind; and it is here that, as a rule, British goods are so much superior to those made both in America and on the Continent. Again, wherever possible, implements and machines should be selected in which the wearing parts can be most easily replaced, and here there is great difference in the productions of the various makers.

Carts and Waggons. Carts and waggons should be made of the best and toughest timbers, especially where the greatest strain occurs, and provided with strong axles, substantial wheels, strong arms and raves, good bottoms, and extra strong angles. Care should be taken in making a selection that the wheels and tyres are of such a width as the nature of the soil demands. Good carts are sometimes—more often in the past than the present—made on the farm where a skilled wheelwright is obtainable. A cart should tip easily, and where intended for use in hay-time and harvest it should be provided with ladders, back and front, which, like the arms, should be liable to as little strain as possible. Carts and waggons should be kept well painted, the best white-lead and oil being used, and always housed under cover when not in use. As a rule, it is probable that more damage is done to both by exposure to rain than by work. A liquid-manure cart is essential upon a farm of average size. There are many makes, some extremely clumsy, others light and strong, with well-arranged mechanism. The metal of the tank should be stout, choking or blocking should be impossible, while delivery should be wide and effective.

The Self-binding Reaper. The self-binding reaper is one of the greatest labour savers in modern agriculture. Few farmers have sufficient experience to differentiate between the various makes and to select the best with certainty. This machine should be little complicated and light in construction—a most important feature—but it should be strong. Bearing in mind the difficulty in the case of a buyer with little or no experience in making such a purchase, we would suggest that instead of depending upon his own judgment he should ascertain from other farmers the results of their experience with the machines they possess, and select that which has done the best work and required the least repair. It is well, too, to see two or three of the best binders at work on similar land to that occupied and on similar crops to those grown by the intending buyer. When a machine is decided upon, the buyer should learn from the seller to appreciate the value of every working part, and how to take the machine to pieces for the removal of breakages, and for replacing wearing parts. The farmer should, indeed, master the mechanism of the binder, and especially learn how far he can himself repair it, and when it becomes necessary to call in the aid of a skilled mechanic. All wearing and other parts likely to be required during harvest should be kept on hand, and especially the knife sections, fingers, rivets, nuts, screws, and sheets.

The Reaper. The ordinary reaper cuts corn like the self-binder, revolving sails sweeping it on the ground in untied sheaves as it falls on the platform, leaving it to be tied by hand. This machine, although heavy to work, is less complicated, and is useful where tying is impossible. A combined grass mower and reaper is made by some firms, removable parts being attached for cutting corn; a second man rides with the driver, and sweeps off the corn by hand in sheaf-size lots as it is cut. In each case wearing parts should be in stock, the machine regularly examined, cleaned, oiled,

painted where necessary, and always kept in workable condition.

Potato Raisers and Planters. The potato planter is one of the newest and most ingenious farm implements. It ploughs two (or four) furrows, plants the seed potatoes at regular intervals—which can be varied at pleasure—covers them over, and forms the rows.

There are several implements or machines in the market which are intended to raise the potato crop with expedition and completeness. The simplest is the ridging plough, to which a specially square-pointed head and breasts are attached. When at work the point of the implement passes beneath the tubers, which, with the soil, are thrown right and left, ready for picking up. A more elaborate machine is made with a broad, horizontal blade, which passes beneath and lifts the potatoes, with the soil and haulm attached, these being separated by revolving tines at the back of the machine. Better and quicker work is performed than with the plough, which necessarily leaves some tubers in the soil, these being recovered only, but not always entirely, after harrowing. A still more elaborate and costly potato raiser, made on a similar principle, lifts the tubers clear of the soil, raises, sorts, and bags them at one operation. It is questionable, however, whether it is really economical in practice to bag potatoes which have not been allowed to remain exposed to the sun and air to dry before picking.

Drills. Drills are made in great variety, but chiefly on two principles. In the cup drill the seed receptacle is carried between two wheels, a second pair of wheels in front being chiefly employed for steering. Passing through the seed receptacle is a rod upon which are discs fitted with small cups. When at work and in gear the rod revolves, the seed is picked up by the cups from beneath, and dropped into vertical cylinders, and thence into somewhat heavy metal coulters, which are drawn through the soil, making narrow furrows, into which the seed is deposited as they pass along. Cups of various sizes are employed in accordance with the kind of seed used, while the quantity sown is regulated by the aid of cog-wheels, which are changeable, and which increase or decrease the revolutions of the cups as may be necessary.

The cup drill does not sow exceptionally large or small seeds, such as beans or grasses, the system of regulating the quantity per acre is imperfect, and there is no possibility of measuring the area sown. The drill, too, is cumbersome and heavy in draught, and therefore slow in work, while it requires more horses and men than should be essential. On the other hand, the force-feed drill is of lighter construction, drawn by two horses instead of three, and worked by a man and a boy. A larger variety of seed can be sown with greater accuracy and speed, and the area sown can be measured.

The Mangel-drill. Small drills, drawn by one horse, are employed for mangels, and here specially formed rollers are attached to fit the ridges beneath the surface on which the seed is deposited. Large numbers of farmers, however, employ the cup drill already referred to, but in this case the ordinary receptacle is removed and replaced by one of larger size, taking both seed and manure, which are simultaneously drilled. Here, again, however, the machine is still more cumbersome and inadequate. The sowing of grass seeds by the aid of a separate attachment is practically impossible with the cup drill, but the practice is followed where the force-feed drill is in use.

The seed-barrow is an implement composed of a very long, V-shaped box with a lid, which is divided by partitions into compartments. At fixed distances there are discs with holes of various sizes, any of which are opened in practice in accordance with the quantity and variety of seed used. Passing through the length of the box is a rod upon which circular brushes are fixed. When in work these brushes revolve and push the seed through the holes opened for the purpose. The seeds sown by the seed-barrow are grasses and clovers, the implement being wheeled across the field by hand. There is, however, no system of regulation beyond that referred to, which is primitive and unworthy of advanced agriculture.

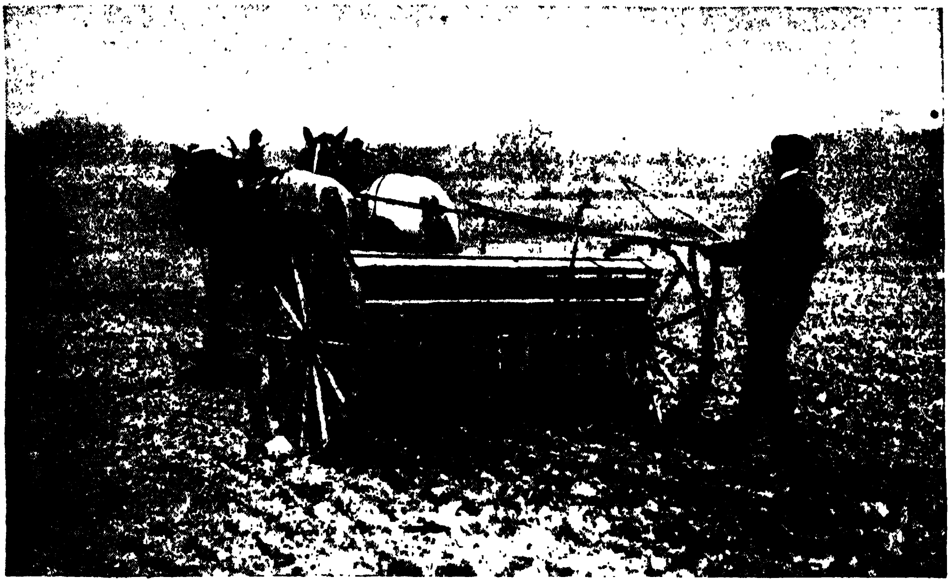
The Threshing Machine. The threshing machine is large and heavy, but cleverly constructed; it is driven by a steam-engine, to which a belt is attached. The machine is placed beside the corn rick, the sheaves or loose corn are tossed on to the platform, passed into the machine by the feeder, the grain is removed from the ears, screened, and in due course shot into a sack suitably placed to receive it. Simultaneously the straw, cavings, chaff, and rubbish—chiefly dust and weed seed—are deposited outside, while the tail, or inferior corn, passes into a second sack. It is seldom that a threshing machine is found upon a farm, the practice being to hire it when required, on conditions which vary more or less in accordance with the practice in the district.

The Straw Trusser. The straw trusser is now made for attachment to the thresher, so that, when required, the straw may be tied in trusses for sale as fast as it comes from the machine. It is costly, but is frequently obtainable on hire, on reasonable terms, from those persons who let out threshing machines.

Presses. Hay and straw presses are now comparatively numerous, and are made for both steam and hand power, the smaller hand machines enabling a capable workman to tie a large quantity of hay—for which they are chiefly used—in a day, string being employed instead of hay or straw bands, which occupy much time in making, while the pressed hay occupies much less space on the waggon and in the railway truck, and consequently costs less for conveyance to the buyer. It is important that the hay press should be strong, and that a weighing apparatus should be attached.

The Weighing Machine. The weighing machine is chiefly employed for granary work, or for checking the weight of cake, manure, and seed. On some farms a weighbridge for weighing stock forms part of the equipment.

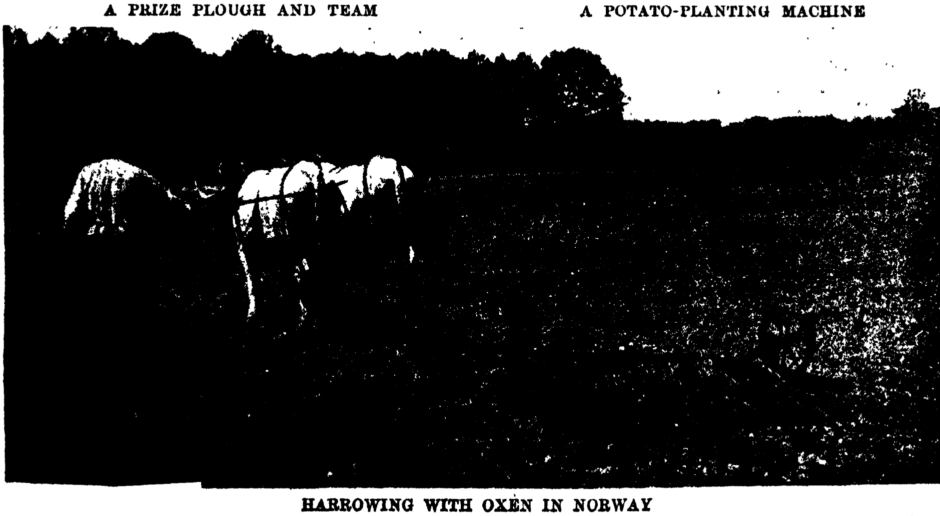
THE EVERYDAY WORK ON THE FARM



SOWING SPRING WHEAT WITH A MODERN SEED-DRILL

A PRIZE PLOUGH AND TEAM

A POTATO-PLANTING MACHINE

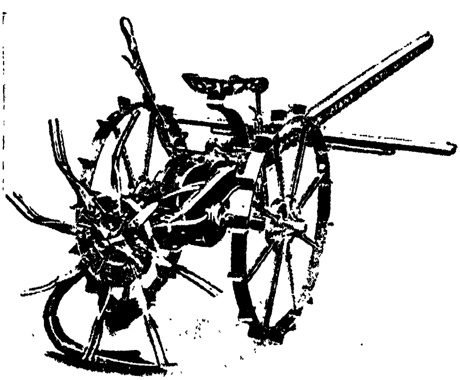


HARROWING WITH OXEN IN NORWAY

The Winnower. Before delivery, the already threshed corn is passed through the winnower for further cleaning and dressing, that the sample may be finer, and realise a higher price. The blast of this machine should be sufficiently effective to remove what is not rejected by the screens and riddles, especially in the case of barley. Hand samples of dressed and undressed barley, wheat, or oats, placed side by side, will show the importance of the process, two or three light grains being sufficient, in the buyer's eyes, to warrant a lower price.

The Mowing Machine. A necessary implement on all farms, the mowing machine is used for cutting grass, clover, lucerne, sainfoin, and mixtures. The knife works on the principle adopted in the reaper, the crop being laid in even swathes. It is important that the mower should be at once light and strong, and among the many makes in the market it is now somewhat easy to obtain what is required.

The Horse-rake and Hay-drag. Made in two forms, it is desirable that the horse-rake should be as wide as possible, in order that a considerable sweep may be taken at one operation. Owing, however, to the limit of the width of gateways, it is necessary that the wider rakes should be expansive and contractive at will, and thus it is that we have the telescope horse-rake. The machine should be light, suitable to one horse, and so simply constructed that the hay, when raked, may be easily released by the driver. The tines should be flexible, and all parts easily replaced when necessary. The horse-rake, which is used for both hay and corn, is now supplemented by the hay-drag, which is drawn by a team of horses, one at each end of the implement. The strength employed enables the driver to collect a very large quantity of hay, and to deliver it at the foot of the rick if necessary.



A POTATO-RAISER

The Haymaker and Swathe-turner. The haymaker is an implement upon which are a number of revolving tines or spring teeth, which pick up the partially made hay, lift, and toss it into the air. The machine practically supersedes the old-fashioned hayfork.

The swathe-turner is a machine which, the upper side of the newly cut grass being dry as it lies in swathe, turns it over cleanly and rapidly, that the under side may be dried also. This machine is one of the most important and valuable on the grass farm.

The Hay-loader. A machine of American invention, the hay-loader is intended to pick up hay as it lies in windrows and elevate it to the waggon, thus dispensing with a couple of men. Its work is rapid and useful, but the land still needs raking in the ordinary way.

The Elevator. The elevator is a large implement, worked by the aid of a horse, which conveys upon metal-tined carriers, travelling on endless chains, the hay or straw from the ground or the cart to the top of the rick which is being built. It is a labour-saving implement of great value, although costly in the first instance.

The Plough. The one implement without which arable land culture is impossible is the plough. The number of makers, and the variety made by each maker, are so large that the buyer of a plough may be excused if he becomes confused and finds selection difficult. Having, however, decided upon the type and the maker, his wisest plan is to ask that a skilled workman may be sent to the farm with a suitable assortment, and that each may be tried on the land, for much depends upon the selection of the best and most suitable implement. Something may be learned by examining the work performed on neighbouring farms if the soil is similar, and noticing the principle adopted. Again, when several ploughs are being tested, it is well to invite neighbouring farmers of experience to witness and criticise the work, and to compare it with their own.

The object of ploughing is chiefly to prepare a seed-bed. To this end the soil may be ploughed sufficiently deep and laid up so that it will pulverise as perfectly as possible. It is also important that the work should be done with as little draught or waste of power, and as quickly as possible. The plough selected should be one in which the wearing parts of the breast, as well as the points and fins, should be replaceable. It may be that a double-furrowed plough will prove the most economical, and that three or four horses, driven by one man, will do as much as two pairs of horses and two ploughs driven by two men, or that a riding plough will better satisfy the ploughman, and encourage him to do more or better work. It is time that the cumbersome ploughs employed in Kent and other English counties were replaced by the modern iron and steel ploughs, which do more, if not better, work, with less draught. Additions for skimming, sub-soiling, and broad-sharing should, if possible, be obtained for attachment to one and the same implement. Steam ploughs and motor-ploughs have been elsewhere mentioned (see pp. 24 and 25).

Harrows. Harrows are of various forms, sizes, and weights. Seed-harrows are light in structure, sharpened tines being fixed with nuts to iron frames. A set usually consists of three or four distinct harrows linked to a wooden bar, to which the draught-chains of the horses are attached. Heavier harrows for working down the soil and preparing a seed-bed are made both with iron and wooden frames, the latter sometimes

being very clumsy. Drag-harrows are provided with bent tines, which enable them to pierce the ground to greater depth, and thus break up clods which are almost or entirely buried. Chain-harrows, made in various forms, consist of a number of iron links, which are usually provided with points on one side. These are intended for work on grass-land in spring, and, as occasion requires, on arable land, especially where it is necessary to collect weeds and other materials brought to the surface by sharp-pointed harrows.

Cultivators, Grubbers, and Scufflers. Implements drawn upon wheels, and provided with curved tines intended for entering the soil, reducing the size of the clods, preparing tilth, and removing weeds, cultivators, grubbers, and scufflers, are made in various forms and sizes. In some cases modern cultivators are combined tools—broad-shares for paring the surface, hoes, and duck-foot shaped points being provided for replacing the tines as occasion requires. The tines, like the other wearing parts named, are raised from the ground by the aid of a lever when the implement is out of work. More recently flexible or spring-tined cultivators have been introduced.

Rollers. The roller is made in several forms, the modern implement being of iron. The weight, width, and diameter of the roller depend upon the work it is intended to perform. It is made to resemble a whole cylinder, or a cylinder in sections, or it may consist entirely of rings, each of which fits loosely on an axle. The clod crusher, another form of roller, consists of rings, which are serrated. The roller is used on grass-land intended for hay, on arable land after sowing, and on land in process of cultivation at various stages, when it becomes necessary to reduce the coarse soil into fine tilth.

The Grinding or Grist Mill. Used on most farms where steam is employed, the object of the grinding or grist mill is to provide the meal intended for feeding stock in general, and for crushing, bruising, or kibbling oats, maize, barley, or wheat. In most instances the wearing parts of grist-mills, which are easily replaced when worn, are made of steel, but where the workman in charge is able to dress his own the stone mill is found the most satisfactory.

The Pulper, or Slicer. The pulper, or slicer, is intended for cutting up mangels and swedes into pulp, slices, or finger-pieces in the preparation of a stock ration. The knives should be reversible or easily replaced, and the machine should be one which cannot clog. The knife discs are usually vertical, but a machine now exists in which they are horizontal.

The Chaff-cutter and Cake-breaker. The chaff-cutter cuts hay and straw into short lengths, either by hand, horse, steam, or other power. The material is placed in a wooden trough, drawn forward by the action of specially made rollers and under the revolving knives, which, fixed on a fly-wheel, pass rapidly over the face of the pressed fodder. It is essential, to comply with the law, that a chaff-cutter should be so constructed that it is practically impossible for the workman feeding it to meet with harm.

The cake-breaker is a machine intended to crush into small pieces the hard linseed, cotton-seed, and other cakes which are used for stock. As each cake is passed into the machine it is seized by the spiked rollers provided for the purpose of breaking it down. In the best machines there are two pairs of rollers.

TRACTION-ENGINE DRIVING A FINISHING THRASHING-MACHINE AND STRAW-ELEVATOR
From a photograph by permission of Messrs. Marshall, Sons, and Co., Gainsborough.

On every farm there are many minor implements and tools which are essential, one or more being in demand on almost every working day. These include hand and drag rakes necessary in the hay and corn field; a hay-knife for cutting hay or straw from the stack; two or three scythes, with stone rubbers; a grindstone, which should be of the best make obtainable; a weighing machine, with a guard to hold up a sack of corn; milking pails and stools; cattle-chains; stable equipment, including cornbin, sieves, brushes, curry and mane combs; lanterns, forks, shovels, brooms, spades, hoes, and rakes for fine work; beetle and wedges for splitting timber; an axe; a cart-jack; various spanners; tools suitable for hedging, cleaning ditches, draining, the mending of gates and fences, and painting of waggons, carts, and the various implements of the farm.

JAMES LONG

Bleaching Powder. Calcium. Metallic Elements, including Aluminium, Magnesium, Manganese, Iron, and Zinc.

MORE ELEMENTS IN DETAIL

Bleaching Powder. Bleaching powder is another very important substance which contains calcium, though this is really not the most important element in its composition. It is prepared by the action of chlorine—its active ingredient—on calcium hydrate, or slaked lime. This last, prepared with great care and free from impurity, is spread out in thin layers over the floor of stone chambers, and then chlorine gas is passed over it. The compound that is formed is of somewhat uncertain composition; it may perhaps be described as a mixture, or rather a semi-compound, of chloride and oxychloride of lime, and its composition may be indicated by the formula CaOClCl. This formula is only approximate, and must not at all be taken as comparable with the other formulas we have seen, which are exact. The reader should be sure that he appreciates what these formulas mean, for he will be greatly handicapped in his study of chemistry until he has mastered its alphabet. (See Chapter 8.) At any rate, bleaching powder contains a superfluity of chlorine, which it is ready to dispose of, and to which it owes its properties.

Another very common salt of calcium is its fluoride, which has the formula CaF_2. This occurs as a very common mineral, very often in association with the ores of lead, and usually known as *fluor-spar*, or *fluorite*.

It forms very nearly transparent crystals, most frequently cubical. It is hard but brittle, and occurs in a large number of different colours, of which the most common is violet. Sometimes it occurs in alternate bands of violet and colourless structure; this form is commonly known as Derbyshire spar.

Salts of Calcium. The *sulphate of calcium* ($CaSO_4$) is an important salt, which occurs in Nature in different forms. One of these, sometimes called *anhydrite*, contains no water, but commoner forms, such as gypsum, contain two molecules of water of crystallisation to each molecule of the sulphate. Other water-containing forms of sulphate of lime are selenite and alabaster. Selenite is practically equivalent to gypsum, and alabaster is almost identical.

The latter has a pearly lustre, is never transparent, is quite soft—in this respect these forms contrast markedly with anhydrite—and thus it can be very readily carved or turned; but it must not be exposed to rain, as it is soluble in water, though only slightly. If these forms of sulphate of lime be heated, there is derived the cement-like substance called *plaster-of-Paris*. In practice this is always obtained from the commonest form, which is gypsum. When heated at a temperature considerably above the boiling point of water, it loses its water of crystallisation, and forms a plastic substance which can be moulded to any form, and which on mixture with water speedily sets into a hard, rigid mass, which consists of a union, if not a true chemical combination, between the water and the salt. It is certainly more than a mere mixture of the two. This we know because a good deal of heat is produced as the plaster sets, and the evolution of heat is an invariable sign of the satisfaction of chemical affinity.

The *sulphide of lime* (CaS) is luminous in the dark, and may therefore be used to amuse children, and so forth. At one time it was largely employed in medicine, but is probably of no particular value as a drug.

The *phosphate of lime*, a compound of lime and phosphoric acid, occurs in Nature as a mineral called *apatite*. It is constantly found in the animal body, forming some 60 per cent. of the structure of the bones, and even a higher proportion of the teeth. Minute quantities of the fluoride of calcium, mentioned above, are also found in the teeth.

Barium. Barium is a very heavy metal which closely resembles calcium in many of its chemical properties. It has recently obtained much fresh theoretical importance from the fact that it seems to have certain relations to radium. Its atomic weight is about 137. Its name is derived from the Greek word *barys*, "heavy," as in "baritone."

Barium is never found in the elemental state in Nature, as a metal, but occurs in the form of two salts—the sulphate, which forms the mineral known as *barytes*, or *heavy spar*, and the carbonate. Like sodium and potassium, barium was first isolated by Sir Humphry Davy. Its oxide closely corresponds to the oxide of calcium, and has a similar formula, BaO. It is known as *baryta*. The characteristic colour produced by barium salts when they are heated to incandescence is green, and some of them, such as the chloride and nitrate, are often used in fireworks for this purpose.

Barium also forms a dioxide (having the formula BaO_2), as indeed does calcium. The calcium salt is of no importance, but the barium salt is used as a means of preparing oxygen in large quantities. In the first place the salt is formed by heating the ordinary oxide to dull redness in air, from which it takes a certain amount of oxygen so as to form the dioxide. When this is heated still further it gives off the extra oxygen which it had taken up at the lower temperature. Instead of thus working with temperature, the same changes may be made to occur by altering the pressure, which comes to the same thing. Air is forced into

tubes containing the oxide, the dioxide being formed while the nitrogen of the air escapes. Then, when the pressure is lowered, the oxygen previously taken up is given off again, and can be collected.

Strontium. The last element dealt with in this group is *strontium*, which is of less importance than any of the others. Its atomic weight is about 87·5, and its chemical symbol Sr. It also was first discovered by Davy, being prepared, as we have already seen, by electrolysis of the fused chloride. It is a yellowish, malleable metal, which readily oxidises on exposure to the air, and also decomposes water in the fashion which should now be familiar. It is found in Nature in the form of the sulphate and carbonate. As in the case of barium, its chloride and nitrate are soluble, and can be used, especially the latter, in fireworks. It produces a splendid crimson colour. The sulphate of strontium is peculiar in that it is less soluble in hot water than in cold.

Magnesium and zinc are the next two metals to be discussed, since they form a group. They are both metals heavier than water, but, unlike the preceding metals, are not liable to act upon it, save slightly, if the water be boiled.

Magnesium. Magnesium is not found in the elemental form in Nature, but is abundant in certain compounds. Of these the commonest are the carbonate, the double carbonate of calcium and magnesium, which is known as *dolomite*, the sulphate (which occurs, for instance, as the mineral Epsomite, reminding us of the medicinal use of the sulphate of magnesium, or Epsom salts), *carnallite*, which is a double chloride of magnesium and potassium, and in the form of various mixed silicates, such as *asbestos*, *tourmaline*, and *meerschaum* (literally sea-foam). Again it is Sir Humphry Davy who first isolated metallic magnesium.

The metal is now prepared from its chloride, from which it is displaced by means of metallic sodium. It is extremely light, insoluble in water, but readily soluble in acids. Its atomic weight is 24, and its symbol Mg. The reader must not confuse magnesium (with the symbol Mg) and manganesium, or manganese, which has the symbol Mn. When magnesium is heated in air it burns with an exceedingly brilliant light, and forms the oxide of magnesium, MgO. This is usually known as magnesia; and is a tasteless, insoluble, light, white powder of considerable use in medicine. It is not, however, usually prepared by the oxidation of magnesium, but by heating magnesium carbonate, which salt is decomposed, giving off carbonic acid in a manner exactly similar to the decomposition of calcium carbonate and the formation of quicklime.

The light produced by the oxidation of magnesium is not only extremely brilliant, but is especially rich in those high-pitched or "actinic" rays which are most markedly powerful in their chemical action on a photographic plate. Hence it is largely used for flash-lights in photography.

Zinc. Zinc has the symbol Zn, and its atomic weight is 65. It occurs in Nature only in combination in the forms of carbonate, usually known as *calamine*, and the sulphide, which is known as *blende*, or "black-jack." Calamine is of no particular importance; sometimes it is powdered, carefully purified, and tinted, for application to the face. It is from the blende that metallic zinc is prepared. The blende is roasted in air, yielding zinc oxide and the oxide of suphur, which is volatile, and escapes. The oxide, which is a powder, is treated with charcoal, which takes the oxygen from it. The operation is conducted at a high temperature, at which the zinc is produced in gaseous form. It is never obtained pure by this process. Zinc does not tarnish readily in the air, and so may be used for coating sheets of iron, and thus protecting them from the atmosphere. Iron thus treated is known as galvanised iron. The zinc is not affected even if the air be moist.

The use of zinc instead of lead in the preparation of paints is of the utmost importance, for lead is the cause of grave industrial poisoning, causing many deaths every year, while the industrial preparation and use of zinc are free from all danger to life and health. When zinc is strongly heated, it readily burns and forms an oxide (ZnO). This oxide is of some use in medicine, being incorporated with lard as zinc ointment, which is soothing to the skin, and feebly but usefully antiseptic.

The chloride of zinc, having the formula $ZnCl_2$, is obtained by evaporating a solution of zinc in hydrochloric acid; it is a very powerful antiseptic, and is the basis of Burnett's Disinfecting Fluid. Zinc forms some important alloys. With copper it forms brass, which is made by melting copper and adding zinc to it; with tin it forms bronze, and with copper and nickel it becomes "German silver."

Boron. The next group of elements we have to consider consists of boron and aluminium, the latter of which is fulfilling its promise of great importance. Boron has the symbol B, and its atomic weight is about 11. It is not to be regarded as a metal. It was first isolated in 1808, the year following the discovery of sodium and potassium. It is not found in the elemental form in Nature, but occurs chiefly as borax, already discussed under sodium. Borax has a very feeble antiseptic property, but this is decidedly more marked in boric acid, or boracic acid, which is derived by the union of water with the oxide of boron. This oxide has the formula B_2O_3.

Boracic acid may be obtained by the action of a strong acid upon borax, but this method is not usually employed, since the acid occurs in Nature in certain springs in Tuscany. From the water of these springs it may be prepared by evaporation. The uses of the acid as a mild antiseptic are familiar. Recent research in the United States has proved that boracic acid is injurious when constantly consumed in foods to which it has been added as a preservative, and regulations now limit its use in this country.

Boron also occurs in large quantities as the mineral called boracite, which is a compound or combination of the borate of magnesium and the chloride of magnesium. It occurs in association with gypsum and with common salt in some parts of Germany. It is of no practical importance, and the same may be said of all the other compounds of boron.

Aluminium. The next metal with which we have to deal—aluminium—is exceedingly abundant, as we have already seen, and has lately become of very great commercial and practical importance. It is a white metal, specially characterised by its extreme lightness. Its specific gravity—that is to say, its weight compared to the weight of water, represented as 1 [see PHYSICS]—is only 2·6. Besides this extreme lightness, which is often of much practical value, aluminium has other useful physical properties. It is ductile, and can be drawn into wire; it can also be readily cast, and can be rolled into sheets. It melts at the comparatively low temperature of 700° C. Aluminium tarnishes very slowly on exposure to air, but it forms alloys which are in this and some other respects more valuable than itself. Its alloy with copper, for instance, known as aluminium bronze, is scarcely liable to tarnish at all; it is of a yellowish colour.

Though so abundant, being a constituent of most rocks, and the characteristic element of clay, aluminium has been very expensive until recent times to obtain in a pure state. At the present time, however, aluminium is prepared by an electrical method which has enormously reduced its cost.

The principle is that of electrolysis, consisting essentially in the passage of a powerful electrical current through molten solutions containing the required product. The principle in present use was discovered about a quarter of a century ago. The material employed for electrolytic production is a mixture of cryolite—the double fluoride of aluminium and sodium, with alumina.

One of the widest practical uses of this metal at the present time is in the purification of iron and steel—a use which is due to the fact that the metal at high temperatures is able to decompose the oxides of nearly all other metals. It makes excellent cooking utensils, which do not break or chip or rust, are exceedingly light, and make no poisonous contribution to the food cooked in them. It is also largely coming into use in some directions in the place of copper as a conductor of electricity.

The compound alumina, which has already been mentioned, may be prepared as a white powder, which is characterised by its great affinity for colouring matters, and is thus largely used in dyeing and colour manufacture. The substance formed by the union of the colouring matter and the alumina is usually known as a *lake*. In its crystalline form alumina is second only to the diamond in the scale of hardness. [See PHYSICS.] Tinted by various impurities, it forms some of the most beautiful of precious stones, such as the ruby, the sapphire, and the amethyst.

A New Group. Our next group consists of one exceedingly important element, *iron*, and four of less importance, *chromium*, *manganese*, *cobalt*, and *nickel*. The sources of these metals are as follows: Chromium occurs mainly as chrome-iron ore, which is a double oxide of iron and chromium; manganese occurs in the form of its oxide, which has the formula MnO_2; nickel occurs in New Caledonia in the form of a silicate of nickel and magnesium; and both nickel and cobalt are found in Nature in combination with arsenic.

These metals are to be obtained in the pure metallic state by means of carbon, which turns them out of their oxides. We may first of all dispose of the four unimportant members of this group before going on to deal with iron, which demands lengthy consideration.

Chromium. Enough has already been said about the source and preparation of this metal; it is extremely hard, and of a grey-green colour. It combines with oxygen in various proportions, the most important compound of the two elements being chromic oxide, which has the formula Cr_2O_3. This is sold as a pigment under the name of emerald-green, an accurate name, since the colour of the emerald is due to small quantities of chromium. There is also a double sulphate of chromium and potassium, which is known as chrome alum. The name is a bad one, since it contains no aluminium. The salt forms purple crystals, which are much employed in dyeing, calico printing, and like processes.

Manganese. Manganese, which must never be confused with magnesium, occurs in Nature in several combinations besides the black oxide (MnO_2) already mentioned. Prepared as stated above, it is a very hard, brittle, whitish metal, which cannot be preserved in air, since it rapidly decomposes the water contained in air, becoming itself oxidised and giving off hydrogen.

Naturally enough, metallic manganese has no commercial uses, but its oxides are used in glass-making; and its alloys with iron, with which it frequently occurs in Nature, are very valuable, as such iron yields very superior steel.

A very useful compound of manganese is the salt known as permanganate of potassium, which has the formula $KMnO_4$. It occurs in the form of small purple crystals. When these are dissolved they form a deeply coloured solution, with a very unpleasant taste, a variant of which is familiar to everyone under the name of Condy's Fluid. This compound contains an excess of oxygen, which, in the presence of water, it is very ready to give up to organic bodies. In consequence of the decomposition which then occurs, the solution loses its purple colour, and becomes a dirty brown, due to the formation of the black oxide of manganese. This change in colour has the advantage that it enables one to see whether or not solutions of the salt have undergone decomposition. The solutions of this salt have been largely praised as antiseptics, and are still very generally believed in, but its virtues have been very much exaggerated. It should be looked upon rather as a deodoriser

than as a true antiseptic. It has only very slight action against microbes, but it helps to complete the oxidation of the products of their action, and thus removes foul smells. It readily stains linen, cotton, and the like, but the stain may be removed by applying sulphurous acid, and then immediately washing out the fabric in water. Its oxidising properties render it very useful, if administered early, as an antidote in morphia poisoning. It oxidises any morphia that may remain in the stomach, whether taken as such or in the form of opium, and thus prevents it from acting. The same is true of snake venom, if the salt be locally applied.

Cobalt. This is a reddish-white metal, found, as stated, in combination with arsenic and also as *cobalt glance*, which is a compound of cobalt, arsenic, and soda. Compounds of cobalt, having a blue colour, are used as pigments, and also for giving a blue colour to glass and porcelain.

Nickel. Nickel is a metal of somewhat more importance than the others, chiefly in virtue of its use in strengthening steel. Steel containing a small percentage of nickel is so much harder than ordinary steel that it is said to offer about 20 per cent. better protection as armour plate for ships than the best ordinary steel. Nickel is also used in the form of an alloy with copper for the manufacture of coins. The subject of nickel-plating is treated elsewhere. The metal closely resembles the others of this group. It is of a silvery-white colour, very hard, though malleable, nad melts at a very high temperature. [See also METALS, pages 1321.]

Iron. Iron is, of course, by far the most important and useful of all the metals, having an extraordinary variety of uses, and being indispensable in the living body, in manufacture, in the arts, and in medicine. Very small quantities of the metal are found in the pure state on the earth, and these only in rocks of volcanic origin. Iron, however, appears to occur extensively in its uncombined form in the heavens, and uncombined or metallic iron is found in quite considerable quantities in meteorites. [See ASTRONOMY.] The most valuable ores of iron are various oxides and the carbonate, these being the compounds of commercial importance. The magnetic oxide of iron, sometimes called *magnetite*, has the formula Fe_3O_4. Another oxide (Fe_2O_3) is known as *hæmatite*, and this occurs in several forms. The carbonate, no less important, occurs in what is called *spathic iron ore*, clay ironstone, or clay-band, in which it is mixed with clay; and as *black-band*, in which it is mixed with coal. Large quantities of these ores occur in this country. Other compounds also have a wide distribution. Iron pyrites, for instance, which has the formula FeS_2, is used less as a source of iron than as a source of sulphur. Silicates of iron occur in many rocks and minerals.

The extraction of iron from its ores, with the methods and processes employed, and the making of wrought iron, are treated fully in other pages. [See METALS, pages 405, 529, 659.] The manufacture of steel, steel alloys, and the special steels, as well as full details of the Bessemer and open-hearth steel-making processes, are covered in the articles beginning on pages 794, 924, and 1040.

Mild steel is now employed for all purposes for which wrought iron was formerly employed, and today steel is better than ever it was—thanks not least to the use of the *microscope* in its study, especially under Professor Arnold, in the University of Sheffield.

Iron Chemically Considered. We will proceed to consider iron from the chemical point of view. The best way in which to obtain absolutely pure iron is by the action of hydrogen gas upon one of the oxides of iron, which the hydrogen *reduces*. To reduce a body is to take oxygen from it; hence a reducing agent itself undergoes oxidation while effecting the reduction of something else. But this pure iron is very unstable, for in the presence of moisture and air it rusts very rapidly, forming various compounds, such as the oxide. For practical purposes, therefore, the surface of the iron requires to be treated with something which will withstand the action of the air. Such a substance is zinc, or, rather, an alloy of zinc and iron. When thoroughly clean, wrought iron is dipped into a bath of melted zinc, which is deposited upon it. This *galvanised iron*, as it is called for some mysterious reason, is in wide use in virtue of its resistance to all atmospheric action. Similarly, the iron may be coated with tin, yielding a product the manufacture of which is a trade involving grave injury to many of those employed in it.

Iron has very marked magnetic qualities. The *lodestone*, for instance, formerly used as a compass by sailors—lodestone seems to mean "leading stone"—is an oxide of iron, and has the formula Fe_3O_4. It is now usually known as magnetite, or the magnetic oxide. Other forms of iron are also capable of easy magnetisation—that is to say, they respond to the attraction of magnets, and can themselves be converted into magnets. Steel has like properties, with greater power of maintaining the magnetic quality.

The other important oxides of iron are ferrous oxide, which has the formula FeO, and ferric oxide, which has the formula Fe_2O_3.

Difference Between "ous" and "ic." Here we may explain, once and for all, the use of these two terminations "ic" and "ous." When the Romans wanted to express fulness, they made an adjective terminating with the syllable *osus*, as, for instance, *amorosus*. In English, we contract this to *ous*, and this termination of English words always has the same meaning as the Latin termination *osus*. For instance, there is our word amorous. Similarly, in chemistry, whenever the salt of a base contains more of that base than another salt, we describe the first by the termination *ous*, and the second by the termination *ic*. Hence, a ferrous salt, or a mercurous, or a stannous tells us by its name that it contains more iron or mercury or tin than a ferric salt, a mercuric, or a stannic.

Other ways of expressing the proportion of the base in a salt must be noted. They consist in attaching the prefixes *per* and *sub* to the second

half of the name of the salt. For instance, the salt $FeCl_2$, which contains more iron proportionately than the salt $FeCl_3$, is usually called ferrous chloride, whilst the second is called ferric chloride. But the salt may be looked at in another way. We may say that the amount of chloride in the first salt is *sub*, which means under; while the amount of chloride in the second salt is *per*, which means through, or thorough, as in the word "perfect." Hence, another name for ferrous chloride is subchloride of iron, while another name for ferric chloride is perchloride of iron, and we may speak when we please of the "sub salts" and the "per salts," to distinguish the two series. Let us now make a little table giving instances of the use of these terms:

Ferric chloride, or Perchloride of iron, or $FeCl_3$.	Ferrous chloride, or Subchloride of iron, or $FeCl_2$.
Mercuric chloride, or Perchloride of mercury, or $HgCl_2$.	Mercurous chloride, or Subchloride of mercury, or $HgCl$.

Iron in the World of Life. We cannot leave our consideration of this metal without referring to its rôle in living matter. Iron is found in all known plants and animals, and plays a necessary part in the chemistry of every living thing. It is thus an essential ingredient of the food of animals and of plants. In all the higher animals and plants—the term "higher" must here be taken as meaning all but the very lowest—iron gives rise to very characteristic substances which have a distinctive colour. Iron is indeed responsible for the colour of life in both the animal and the vegetable world. The characteristic colouring matter of the animal is the red of its blood. This red is due to an exceedingly complicated substance—believed by most chemists to have the most complicated molecule that is known—which is called *hæmoglobin*. In every molecule of this substance there is always one atom of iron. The process of breathing depends essentially upon the presence of this substance, which has the power of taking up oxygen from the air in the lungs, and then carrying it, by means of the circulation, to the tissues which need it.

The colour of life in the plant is the green of its leaves. This green substance, which is found occurring in minute granules situated at the circumference of the cells of the leaf [see LIFE AND MIND], is known as chlorophyll, and iron is essential in its construction. If a plant be nourished in such a fashion that no iron can gain access to it, it will come up blanched, containing no chlorophyll whatever, will very soon die, and will be unable to propagate itself. The service which the iron performs for the plant is exactly the converse of that which it performs for the animal, for whilst it enables the animal to help itself to oxygen from the air—oxygen which is then combined with carbon, and given back to the air in the form of carbonic acid, CO_2—it enables the plant to decompose the CO_2 in the air, taking the carbon into itself, as the most precious ingredient of its food, leaving the oxygen behind. Ultimately the tissues of the plant serve as food for the animal, which oxidises them by means of the oxygen obtained in the manner we have described. So the round continues; and the reader will see that iron thus plays an all-important and double part in that incessant and complementary series of chemical changes in the animal and vegetable world which has been called the cycle of life.

Carbon the Most Important Element. The next element which we have to consider is known as *carbon*. It is the most important of all the elements, and needs very detailed consideration. In the first place, we must note that the chemistry of carbon has two distinct aspects, only one of which we can deal with at present. Reference has already been made to the fact that what used to be called organic chemistry is now known as the chemistry of the carbon compounds, and to that we must return later. Here we shall have quite enough to do to consider carbon in its behaviour uncombined, or forming the simplest compounds with oxygen.

Unlike the elements which we have lately been considering, carbon is not a metal. It may be obtained from compounds, such as the oxide, by means of hydrogen or potassium at a red heat, since these elements will reduce the oxide and leave free carbon behind. Perhaps the purest carbon, however, is prepared by heating sugar, which is a compound of carbon, hydrogen, and oxygen. If sugar be heated to redness in a closed crucible, it is charred—that is to say, the other elements are driven off, and carbon remains.

But carbon occurs in Nature in the uncombined state, or, rather, in several states. The *diamond* is a form of carbon, so is *charcoal*, and so is *graphite* (from the Greek *grapho*, I write), which is the mis-called lead of lead-pencils. Now, this fact—that carbon may exist in such widely different forms—is an illustration of a general property which many substances possess, and which we cannot do better than discuss here.

Allotropy. Allotropy is the name applied to this property. It is sometimes also called physical isomerism. Chemically, the substance in question is the same in each case. Physically, it differs profoundly; sometimes it is crystalline, as in the case of the diamond; sometimes it forms crystals of an entirely different kind, such as graphite; and sometimes it is not crystalline at all, like charcoal. The technical name for a substance which is not crystalline is *amorphous*, literally meaning shapeless. Other elements have this property of allotropy besides carbon, instances being phosphorus and sulphur; and numerous compounds have the same property, such as silica, the oxide of silicon, which occurs in the amorphous state, and also in crystalline forms, such as the agate and quartz. The explanation of allotropy is hard to discover; perhaps the most obvious fact connected with it is that the change of physical state usually depends upon a change in temperature. Let us now return to the various allotropic forms of carbon.

C. W. SALEEBY

The Noble Roman Character that was Attained by Effort and Lost by Ease

THE SPIRIT OF ANCIENT ROME

GREEK and Roman civilisations are two component parts of one great whole. Politically the form of state and the ideas of government which we meet in Greece and Italy are substantially the same. Greek literature, art, and science survived with abundant vitality throughout the period which we roughly call Roman; in half of the Roman Empire Greek was the universal language, and every educated Roman of the later period spoke and wrote Greek almost as easily as Latin. Roman literature was modelled upon Greek; every Roman poet thought it a matter of duty to imitate some Greek original. The Christian fathers wrote both in Greek and Latin, and thus Christian thought was passed on into the Middle Ages strongly tinged with both Greek and Roman ideas.

Yet Rome was very far from being merely an outgrowth of Greece. Greek ideas were grafted on to her stock only after it had attained a certain maturity of its own. Rome made an independent contribution to the great whole which we may call Mediterranean civilisation, and thus also to the civilisation which we may call modern and European. The Roman spirit, though it came to be so greatly affected by the Greek spirit as to tempt us to call it Græco-Roman, did in reality survive all through the history of the Roman people, and it is the aim of this section to trace it continually at work.

What was the contribution of the Romans, as distinct from that of the Greeks, to that great Græco-Roman whole on which our modern civilisation is so largely based? We can separate it from the other chief contributing element if we steadily bear in mind two facts. First, Rome became the guardian of Greek civilisation after the political and material decay of Greece; she supplied the military force and the organising genius which saved the choicest products of the Greek spirit for centuries from destruction at the hands of the semi-barbarous peoples of the east and wholly barbarous peoples of the north; and when at last the invaders broke through the barriers she had planted, her spirit was still so completely in the ascendant as to move them with an awe which secured the immortality of her long-guarded treasures. Secondly, the Roman genius for public and private law supplied a common basis of orderly life for the whole Græco-Roman world. Mommsen, the great historical exponent of Roman law, defined law as state interference in the interests and passions of humanity.

Applying this to the work of Rome in the world, we may say that in her a state power at last arose, after long periods of tentative and unintelligent government, which did so effectually interfere among the interests and passions of humanity in that Græco-Roman world that we still feel it at work among us. The Roman "civil law" is still the basis of our best conceptions of jurisprudence. These two facts, the military defence of civilisation, and the legal ordering of human life, may both be summed up in a single expression—the Roman peace (pax Romana). Roman arms defended civilisation, allowing no enemy to invade its sacred precincts; and Roman law was thus able to develop itself leisurely and peacefully, to the infinite and permanent benefit of mankind. Incidentally we may note that room was found under this Roman peace for the growth of Christianity, the most remarkable phenomenon of the later Græco-Roman period.

This result of the work of Rome shows us that the Roman had two great qualities which were denied to the Greek, and which, taken together, constitute what we may call the Roman spirit. The Roman could fight, not only in short campaigns or in single battles, but in long and protracted struggles, constantly defeated, yet never permanently losing ground, and holding tenaciously to the main object of securing a territory or organising a frontier. And he had the power of orderly government, taking shape not merely in a neat legal code suited to a single city-state, but adapting itself to the needs of a great variety of peoples, incorporating their usages, learning from their experience, yet subordinating all this variety to a single

great end. In the possession of these two qualities the Romans seem to have stood alone among all the peoples of the Mediterranean basin. We see them at work throughout Roman history, in spite of many dark periods and many national shortcomings. Can we account for them by any reference to early Roman experience?

Rome's Place in Italy. We get an idea of the conditions under which they developed, even if we cannot altogether explain them, by fixing our attention on some unquestioned facts in the early history of Italy. Let us look at the map, and mark well the position of Rome in relation to Italy and the peoples inhabiting it. The long, narrow peninsula is cloven in two parts by the River Tiber, the largest stream south of the Po, draining almost the whole middle portion of the mountainous region of Central Italy. The whole country to the north of the Tiber, when Rome first appeared on the scene, was held by the Etruscans—a mysterious people, whose origin is still unknown, a warlike people, spreading their dominion far to north and south, and an adventurous people, building fleets and engaging in commerce in the Western Mediterranean. To the south of the Tiber lay the territory of the Latins, extending over what we now call the Latin Campagna, on which from east and south the outskirts of the Apennines look down, then inhabited by peoples related to the Latins, but at constant feud with them. The natural centre and citadel of Latium is the Mons Albanus, which rises some miles to the south of Rome to a height of 3000 feet. But this was too far from the river, the natural frontier against the Etruscans, to defend the Latins from these enemies; what was needed was a citadel of refuge, and an outpost to anticipate the need of such a citadel.

The Advanced Outpost of the Latins. Rome was this outpost; sitting astride of the river in the post of danger, about twenty miles from its mouth, holding land on both banks, guarding the sacred wooden bridge which might be broken at any moment, and owning the mouth itself of the river, with a settlement there by way of port (Ostia), she was obviously exposed to continual strain, while the kindred and allied peoples in her rear enjoyed comparative peace. Here we have something at least of the secret of Rome's genius for war; her training in the art of war was not of a petty community apt to attack a neighbour or to be attacked by him, to raid or be raided in the course of a summer; it was that of a people having a continual duty before them, many miles of frontier to hold, constant liability to surprise and defeat, yet bound by sheer necessity to cling for very life to their position, and when and where possible, to advance and strengthen it.

Taught by War. Such advance, as time went on became ever more possible and more tempting; the Tiber valley was the natural entrance into the heart of Italy. So it came about that the Romans, having learnt their lesson of military endurance in the school of defensive warfare, were able to put it to use in the slow but steady acquisition of the dominion of the whole peninsula. For of them alone could it be said, as the historian Tacitus said of the Chatti people in Germany, that other peoples went out to battle, but the Romans went out to war.

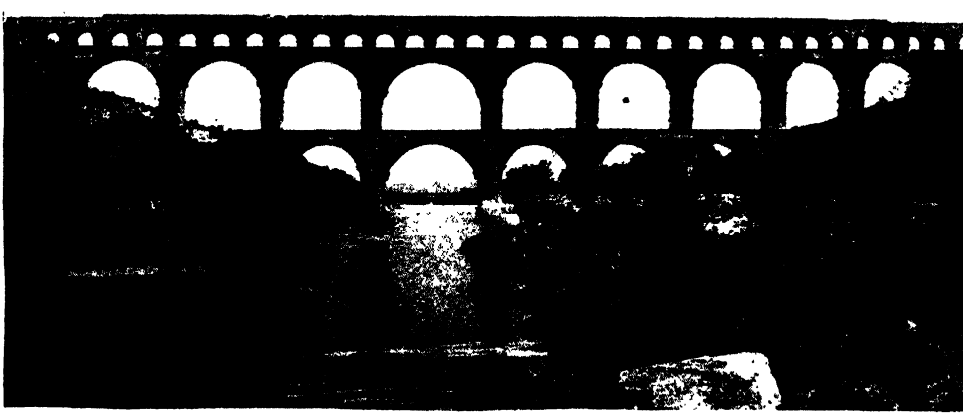
But warfare of this steady, dogged kind, in which the Roman people have hardly ever been equalled, cannot be carried on without a habit of discipline, of obedience to constituted authority, for which the military position of Rome will not by itself account. To explain this we must turn to that other great quality of this wonderful people—the instinct for law and government. Can we find, in the internal organisation of the Roman people, or in their early experience, anything which helps us to explain not only their later genius for law, but their instinct for order and discipline?

The Father as Chief. One fact will go a long way toward supplying the explanation. From the earliest times the basis of Roman society was the family; and the family was organised and governed on a principle at once simple and stringent. It was under the absolute authority of the head of the household (pater familias), subject only to the tradition that in matters of great moment he should consult his relations in a family council. Wife and children were "in his hand," and had no legal status of their own; and in all the relations of the family to the beings both human and divine who dwelt around them he was absolute arbiter. He was chief priest of the family, and on his knowledge of the ritual necessary to the propitiation of its deities or the discovery of their will the very existence of it depended; for without the proper rites and formulæ—so the Romans at all times firmly believed—the gods could not be induced to perform their functions as guardians of the land and its products, on which the family subsisted. Thus there must have grown up, long before the state came into being, the idea of authority, both civil and religious, vested in a single individual, to defy which was almost impossible and unthinkable, because the welfare of the ruled depended absolutely on the ruler.

The Roman Genius for Discipline. It was natural that the state built upon a concentration of families should base its order of government on the same ideas and traditions. In the earliest form of Roman state of which we know anything, the king (*rex*) was the sole interpreter of civil and religious law, subject only to the tradition that in civil matters of great moment he should consult a council of heads of families (*senatus*), and in matters of religious difficulty a college of persons skilled in religious law and ritual (*pontifices*, *augures*); in war he was probably even more absolute than at home. Thus there developed itself that wonderful conception, the *imperium* of the chief magistrate, of rex in the earliest age, and of consuls and their representatives afterwards, in which a Roman of all ages recognised a state force, which it was practically impossible for him to defy, because, like the members of the family, he had learnt that all

that made life worth living for him depended upon his obedience to it. For this famous word, *imperium*, the Greeks had no real equivalent; it sums up the genius of the Roman for discipline, whether in the observance of civil and religious order at home, or in obeying his commanders in the field.

The Typical Roman Character. Thus the Roman character was built up by external warfare and internal discipline. This character was not altogether a pleasing one; but it was admirably adapted for the work Rome had to do in the world. The typical Roman was hard, stubborn, narrow, unsympathetic; he was intellectually somewhat slow, wanting in the quickness and versatility that characterised the Greek; wanting also in imagination, and in the adventurousness which is the practical side of the imaginative faculty. Deeds pleased him more than words, and it was long before he began to learn the wonderful resources of his own tongue. Seriousness (*gravitas*) in all his conduct, public and private, was the quality he most admired, and this was expected also in married women, and even in children. He was not indeed without a certain sense of humour, but his humour was rough and apt to be coarse, and later on in literature developed into satire, the one original contribution of the Romans to literary form. In morals the Roman seems to have been strict rather than delicate, and always more lenient to the man than to the woman; in religion he was—like all Italians, ancient and modern—peculiarly superstitious, but here his natural tendency was checked and regulated by his religious law and its administrators. This and all other tendencies to emotional excess or display were discouraged both in public and private life; marriages "for love," for example, were quite unknown, and at all times in Roman history love was an illicit passion only. The emotional characters with whom we meet in later times, such as Cicero and Catullus, were not Roman by descent; and Virgil, who stands alone in Roman literature for sympathy and tenderness, was perhaps of Gallic blood. Cæsar, on the other hand, a true Roman by birth, had all the old characteristics of the race, but tempered by the courtesy and *humanitas* which had come in with Greek education, and a much wider experience of the world.



THE FAMOUS ROMAN AQUEDUCT AT NIMES, FRANCE

The character thus built up was put to severe trial. The invasion of Pyrrhus and the long first struggle with Carthage strained the endurance and resources of the people to the utmost; but the war with Hannibal was a trial such as no people has ever gone through before or since, and survived. It was, however, the Roman spirit that saved her—the "courage never to submit or yield," the tenacity that was the result of an imperfect education and a narrow range of vision. For fourteen years her deadly enemy was in Italy, bent with an incredible vindictiveness on her destruction, ever victorious, and with famine and pestilence at his heels; but the great Roman families never gave up hope or allowed themselves to be beaten; and the people, trained to trust them, never really failed to answer to the call of duty. Whoever would really understand the Roman character, with all its strong and weak points, should read the story of this great struggle, and note how in such a crisis in the history of civilisation the victory lay ultimately with the people that could endure and obey.

The Cost of Strain. That study is the more valuable, because from this time forward the Roman character began to deteriorate. Rome passed safely through the struggle, but at the cost of the best part of her strength, moral as well as physical. The strain had been too great for her, and, indeed, for Italy as a whole. It is difficult to trace the subtle processes by which such a trial can affect the nervous tissue of the people, weakening its virility, laying it open to the temptation to indulge in ease, to look for wealth and comfort, and so gradually destroying the sense of duty toward family, state, and gods.

And here, indeed, it is not possible to say more than that a careful study of the two centuries that followed the war will show that, alike in family life, in religion, in the performance of state duties, the Roman fell rapidly away from the old ideal of conduct; the true Roman spirit seems to have vanished. The state went on conquering and organising her conquests. Rome became the arbiter of the whole civilised world; but the spirit in which the work was done was not that which had built up an Italian federation, and driven Hannibal out of Italy.

The Loss of Public Spirit. It is now the individual Roman who seeks his own advancement. This simply means that the best qualities of the old type were failing, and the worst gaining strength. The individual had been subordinated to the state, and had found his best life in that subordination. In forgetting the state and working for his own ends, he simply gave the chance of growth to all his lower instincts, and neither Greek philosophy nor an improved system of education had the least power to check this growth permanently. We meet, indeed, with a few leading men of a finer type than Rome had yet produced; but the typical Roman of this age was the man who gained office by corruption, plundered the provincials whom he was called upon to rule, and then retired into luxurious ease to enjoy the fruits of his misdoings.

Results of Corruption. The result was that Rome ceased to perform adequately that function for which, as we saw, she was wanted in the world; Mediterranean civilisation was no longer protected securely from enemies within and without. In the western half of her empire wild tribes from the north invaded the province of Gaul at the end of the second century B.C., and finally penetrated even into Northern Italy; and the defeats the Roman armies suffered at their hands were due, not to the skill of the enemy as in the Hannibalic war, but to bad discipline and the corruption of generals. Then for nearly forty years Mithradates of Pontus continued to menace the Greek half of the empire, and at one time overran the province of Asia, and was with difficulty beaten back from the walls of Athens. The sea was infested with pirates, and no traveller's life or property was safe. All this was due to the supineness of the Roman government, and to the violence of party faction, in which the true interest of the state and of civilisation were lost to view. The Senate, the great council which had carried Rome safely through so many dangers, seemed to have lost its capacity for business, and wasted time in personal quarrels or in the interests of individuals.

Even after it had been reorganised and politically strengthened by Sulla it failed to hold the empire together effectually, and each provincial governor ruled his province only for his own advantage, or for the advantage of the companies of tax-collectors (*publicani*), with whom all Romans of property invested their capital. Thus the administration of the law was unsound and corrupt throughout the empire, for in every province it depended on the caprice of the governor, and the money extorted from the provincials was used at home for corrupt purposes in the courts. The genius of Rome for law as well as for warfare might well seem to have deserted her. Unless the Roman spirit could be revived, the prospect for civilisation was dark indeed. True, Roman literature grew in this melancholy period into greatness; the intense individualism of the age left us at least one valuable legacy in the works of such men as Cicero, Lucretius, and Catullus; sound and able men like Mucius Scævola, and Sulpicius Rufus carried the philosophic treatment of jurisprudence to a height which it had never yet reached in any state. But in the field of action, whether in war or government, we can hardly find a trace of the old Roman spirit.

The Lost Roman Spirit. Yet this spirit was to be revived, but not in the body politic. That body politic no longer existed; the Roman city-state had been merged in something new and strange, which we call empire, but to which the Romans themselves were only just beginning to apply that famous word of theirs—*imperium*. The Roman citizen body was scattered all over this empire, and probably the meanest part of it was that which played at politics for money in the capital. The forms of the old constitution were still there, but they were forms without substance. No vital force underlay them; neither magistrates nor senate, and not even the people, understood what the condition of the civilised world called on them to do, or had the will and energy to do it.

The Reviving Influence of Julius Cæsar. If in such an age the Roman spirit was to be revived, this could be done only by the character and genius of some individual having the necessary understanding and the necessary will, the understanding capable of grasping the conditions of the problem which Rome had to face—the defence of the frontiers and the internal organisation of the empire—and the will to carry this work through with infinite patience and perseverance. The actual material for the accomplishment of this great task must now be drawn not only from Rome or even from Italy, but from all the resources of the empire; the army must henceforth be organised on an imperial basis, and the host of workers in the domain of peaceful organisation must be recruited from east and west alike. But the animating spirit of it all was still to be Roman, and, if it was to be found anywhere, must be found in an individual Roman of genius and industry.

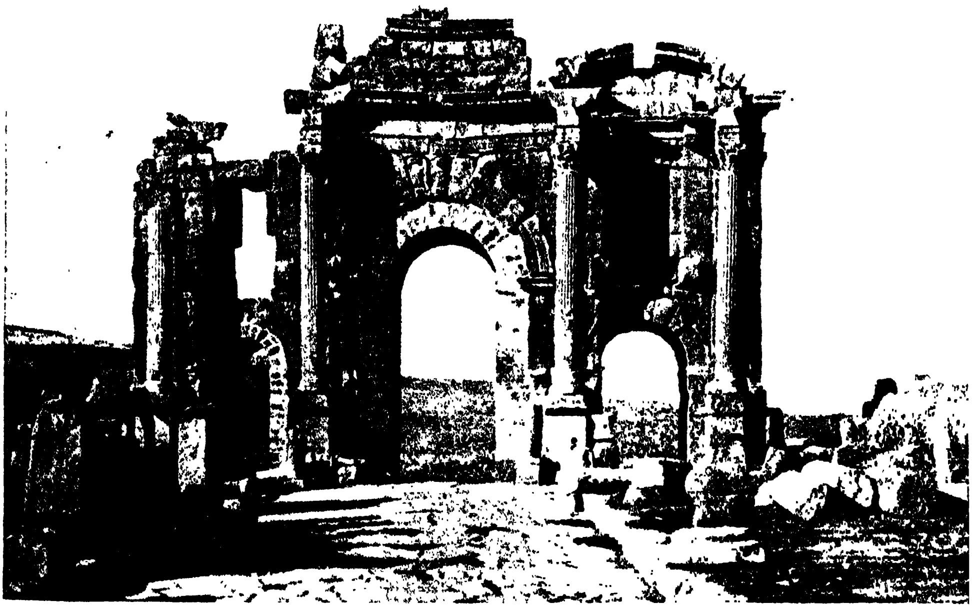
Such a man was Julius Cæsar, a true Roman of one of the oldest patrician families, and, as has been already said, not without some traits of the old Roman character. We may allow that for the greater part of his life, like most of his contemporaries, he was playing for his own hand; but the last fifteen years of it he spent in continual hard work, to which he brought an amount of insight and determination such as had never yet been combined in a Roman states-

man. His first work was the creation of an army thoroughly disciplined, ready to go anywhere and do anything, with which he conquered the great province of Gaul, henceforward to become the most valuable of all the Roman possessions, and established a permanent frontier for the empire in the Rhine and the ocean, removing far from Italy all danger of immediate invasion.

The Waker of the Roman World. That he found himself compelled to use this army for the overthrow of the old constitution we may regret, but in this he was perhaps more sinned against than sinning. When he had grasped supreme power, he went on indefatigably with the work of internal reform; and all that he had time to achieve before he was struck down by fanatical assassins shows the same keen scientific intelligence that marks the conquest of Gaul as we know it from his own Commentaries.

of that time were fairly amazed at the audacity, energy, and ability of the new master. But there was also resentment, and Cæsar's opportunities were cut short. If we wish to study the new Roman spirit, as it was applied to the necessary work without let or hindrance, we must turn to the long reign of Augustus, the nephew and the pupil of Cæsar.

Cæsar's Pupil. When Augustus became master, after the defeat of Antony at Actium, the empire was in chaos and confusion, the frontiers undefended, the provinces disorganised, the finance unscientific; and for many years men's minds had been given up to apathy and despair. When he died, forty-five years later, the pax Romana was firmly established, the empire was knit together in every department of government, the frontiers were adequately defended by an admirable standing



THE ENDURING REMAINS OF ROMAN CIVILISATION—THE TRIUMPHAL ARCH OF THE EMPEROR TRAJAN AT TIMGAD, ALGERIA

His work is indeed only a torso; not only the internal reorganisation of the empire but the completion of its military frontiers had to be left for others. Yet if we ask who it was that inaugurated the new type of Roman spirit—the spirit of hard work and rational intelligence in matters both military and civil—there is, it must be acknowledged, but one answer.

Cæsar woke the Roman world from the lethargy which had so long been paralysing it, and stood out as the visible impersonation of the Roman state and its function in the world at a time when men had almost forgotten that there was a state claiming loyalty, and an empire demanding efficient work. We have a large correspondence surviving from the years in which he was in supreme power; and the impression it leaves on the mind is that the men

army, or by the prestige arising from the long successful reign of the ruler, and, what was perhaps even more important at the moment, Augustus had succeeded in creating an almost universal confidence in himself and his government, and in renewing the conviction that it was the mission and the destiny of Rome to defend and to govern the whole civilised world.

This confidence and conviction are fully reflected in the literature of the age, and more especially in the history of Livy and in the Æneid of Virgil. The historian's part was to recall men's minds to the wonderful story of the growth of the Roman dominion, to induce them to look back on the past and be worthy of their great ancestry. The work of the poet was to paint a national hero, endowed with qualities

which every Roman would recognise as the finest of his race; to tell the story of that hero's divine mission, to which he faithfully adheres in spite of many dangers and temptations. In a form which all educated men could appreciate, the Æneid showed the Divine Will guiding the Roman state from infancy onward, and individual passion forced to give way not only to the will of the gods but to the interests of humanity.

Augustus and the Roman Spirit. The Æneid pointed to duty as the virtue which alone enabled Æneas to fulfil his mission, and which alone could qualify Rome and Augustus to fulfil theirs. In the Æneid the Roman spirit is indeed idealised; but this itself explains why it took such strong and permanent possession of the Roman mind. Augustus himself was no heroic character, and the great impression he made on the world can be explained only by the persevering industry and unfailing good judgment which he and his chief helpers devoted to the defence of the frontiers and the organisation of the provinces, thus at once exemplifying and stimulating the true Roman genius for warfare and for law.

The Industry of Augustus. To appreciate this industry follow the story of the establishment of the military frontier from the mouth of the Rhine to the Euxine, which, as the map will show him, was a screen effectually covering all Græco-Roman civilisation from Spain to Asia Minor. In this story he will find the old Roman genius for protracted persevering warfare fully illustrated, and in the man who bore the brunt of the work and wore himself out in the prosecution of it—Tiberius, the stepson of Augustus, and afterwards his successor—all the true Roman caution and tenacity of purpose, shown especially at one period of extreme danger, in which he may almost be said to have saved Italy and the empire. Or let him follow the work of Augustus himself and his faithful helpmate, Agrippa, who spent year after year in reorganising the provinces both in east and west. This means that every community in the empire, and every individual in each community, was placed in a definite legal status, was secured in respect of his person and his property, and was no longer at the mercy of rapacious tax-collectors or provincial governors. His status (*jus*) might, indeed, be an inferior one; he might not have attained to any part of the Roman citizenship; but the central government now had a long arm, and as his legal position was defined and recognised, redress was to be had if injustice were done him. And in the course of the next two centuries the *jus* of all communities of all free men was gradually raised to the same level; the Roman citizenship was extended to the whole empire, and the Roman law—the interference of the state in the interests and passions of humanity—was administered in every court.

The Roman spirit, in this new phase of its being, can be discerned not only in the civil and military history of the empire, but in the great works of architectural art, bridges, aqueducts, amphitheatres, triumphal arches, of which the huge remains are still to be seen wherever Roman occupation left a lasting mark on the land. They are not the beautiful handiwork of a gifted race, but they seem to tell us of strong will, powerful organisation, love of things large and lasting. They are all on a large scale; size predominates over beauty, and details are wanting in delicacy and in true relation to the whole; the eye does not rest on them so much in admiration as in wonder. Here is laborious tenacity of purpose, never that inherent love of perfect proportion that inspired the Greek artist.

The Practical Spirit of Rome. The tendency may be seen in the sculptures crowded with soldiers and captives adorning the triumphal arches—and in the realistic portrait-busts of men who defended the frontiers or governed the provinces. Even in the greatest Roman poets, even in Virgil himself, some trace of the same spirit is visible; here, too, realistic descriptions and crowded scenes may be compared with the inimitable touch of the Homeric story-teller; and the minor poets, Statius or Silius Italicus, are as monotonously lengthy as the Coliseum is monotonously huge. Individual genius is absent or suppressed; the artist works on traditional lines, whether he produces poems, buildings, busts, or even coins, and does not indulge his fancy—because fancy, like adventure, was no part of the Roman mental equipment. Solid practical work, obvious to the eye in the public places of a crowded city, obvious to the mind in all the intercourse of human life—this was what the Roman spirit expected from all her great men, whether soldiers, legislators, or artists, and with this from first to last it was faithfully supplied.

Rome as the Protector of Civilisation. This is not the place to explain the weak points of the Roman empire, or the internal cankers which slowly paralysed its strength. The real value of the empire to mankind lay in the fact that for four centuries it did effectually protect the civilisation which had been developed in the basin of the Mediterranean, and by an elaborate internal organisation raised the whole level of human comfort and confidence. Thus, the chance was given to Christianity to grow, with comparatively few interruptions, into a universal religion of high and low, rich and poor; and as the invaders also gradually embraced this religion, there arose upon the ruins of the Roman dominion the new, far-reaching organisation of the Church of Christendom, inheriting not a little of the old Roman spirit, as well as of the prestige of the great system on which it was built. The Holy Roman Empire of the Middle Ages was rather an idea than a fact of overwhelming importance to mankind; it is in the Latin Church, with its genius for law and organisation, and with its popes and their claim to universal supremacy, that we may see the legitimate heir of the Roman dominion.

W. WARDE FOWLER

Earthwork. Mixing and Laying Concrete. Ferro-concrete. Brickwork and Masonry. Timber and Piling. Ironwork.

VARIETIES OF CONSTRUCTION

It will be useful, before studying the details of any one class of construction, to obtain a general idea of the various materials employed and the modes of using them.

Earthwork. Excluding the use of earthwork in military defences, earthwork may be said to be used only in embankments in one form or another, and of these, railway embankments form the largest proportion. In designing railways, endeavour is made to obtain the minimum gradients, and at the same time to arrange the levels so that the amount of material required to form embankments may equal the amount excavated in forming the cuttings. If surplus material be excavated spoil banks have to be formed to get rid of it. These are filled up to rail level, and may sometimes be utilised in forming sidings, but often they are so much waste; while if there be a deficiency of material from the cuttings it is necessary to obtain a supply from elsewhere at an increased cost. The side slopes will depend upon the nature of the material. In solid rock the sides may be vertical; in chalk, which is soft rock, they may be nearly vertical; in gravel and compact earth they may be 1 to 1, or 1½ to 1—that is, 1½ horizontal to 1 vertical; and in clay they may need to be as flat as 2½ to 1, or 3 to 1. A general average may be taken for the side slopes of 1½ to 1, both in cutting and embankment. As a railway embankment starts from a cutting with no vertical height and increases in depth until the centre of the valley is reached, the most convenient method is to tip the material forward, over the requisite width. For a single line of railway two tips in the width may be sufficient, but for a double line of rails with a surface width of, say, 26 ft., four tips will be necessary, otherwise the material will roll from the centre outwards and the embankment will be liable to slips.

A longitudinal section through the embankment should show the layers in lines inclined forward from the cutting [1], while a cross-section should show the layers in lines [2]. Wherever a stream crosses the line at the bottom of a valley, or on the side of a hill, a culvert has to be formed to allow of the passage of the water during and after completion. This may be merely a wooden box-like trough, or may be like a miniature tunnel in brickwork or masonry. In either case it has to be formed before the embankment is carried over it, and, to prevent pushing it over, it is necessary to tip on both sides of it until it is fairly covered.

Settling of Earthwork. The excavated material occupies more space than it did before it was disturbed, the increase in bulk averaging as follows: Gravel, 7 per cent.; gravel and sand mixed, 8 per cent.; clayey earths, 10 per cent.; light, loamy soils, 12 per cent; soft rock, 30 per cent.; hard rock, 40 per cent. After the embankment is made it naturally consolidates by the action of the weather and the efflux of time: Generally, with the ordinary materials, 3 or 4 in. additional height for every 6 ft. in depth is allowed for settlement, otherwise the embankment must be made up to keep it to "grade level." Rankine says—"Embankments settle after their first formation . . . . . seldom less than one twelfth and seldom more than one-fifth of the original height." But this greatly depends upon the amount of rainfall during the construction: dry lumpy soil leaves most vacant spaces. The ballast to form the road is generally flint gravel, slag, broken stone, or burnt clay, to obtain better resistance to the action of the weather.

Earth Dams. These are embankments formed at the mouth of a valley to shut in the water in forming an impounding reservoir. The general section is as shown in **3**, where the dotted lines indicate the slope of the layers in the formation of the embankment. The essential feature is an impervious wall of puddled clay in the centre to prevent the percolation of water from one side to the other, the smallest leak being extremely dangerous. Selected material is placed next and almost any kind is used outside to give the mass necessary for stability. The puddled clay must be sufficiently protected on the top to avoid any possibility of drying and consequent cracking. The outer and inner slopes depend somewhat on the natural slope due to the material, but they are usually 3 to 1 on the inner or water side, and 2 to 1 on the outer side.

At the back of any retaining wall the earth must be benched out as in **4**, and the material that is filled in must be rammed in layers inclined from the wall. It will thus be seen that in every case particular care must be taken to minimise the tendency to slip.

Concrete. Concrete is made in two main varieties—lime concrete and Portland cement concrete. Lime concrete is the cheaper and is used only in foundations, but is of no more utility than a similar amount of gravel, and in damp situations may even be worse. Wherever it is necessary to use any concrete, Portland cement should be employed, but an exception may be made in favour of Lias lime concrete where this is readily procurable. Cement concrete consists of 1 part of Portland cement, by measure, to 1 or 2 parts of sand as the matrix, and 4 to 8 parts of broken brick or stone, flint pebbles, clinker, coke breeze or other

hard material as the aggregate, varying in size according to the purpose. The theory of the mixture is that the spaces between the larger pieces of the aggregate should be entirely filled by the smaller pieces, that the spaces still existing should be filled by the sand, and that the whole of these materials, including the sand, should be thoroughly coated with the cement, and form a solid mass which shall offer great resistance to compression. Other things being equal, the resistance will vary with the ratio of cement to aggregate. For suspended concrete floors and for thin concrete walls, a mixture of 1 to 4 is used, and the largest pieces of the aggregate must not exceed 1 in. in any dimension.

Complete cottages and blocks of industrial dwellings have been built entirely of concrete, but they are not popular. It is difficult to prevent the walls from cracking, the rooms are said to be cold and cheerless, to echo considerably, and to have moisture deposited on their surfaces, due to their non-absorbent character, upon a sudden rise of temperature. For heavy retaining walls [**5**] and foundations the mixture may vary from 1 to 6 up to 1 to 8, according to circumstances, and the largest pieces should pass a 2-inch ring gauge. It is most important that there should be no clay or earthy matter in the mixture as this would cause a thin coating of mud over the sand and aggregate, and prevent the adhesion of the cement; this is what is meant by sharp sand. All sand has been formed by attrition in water, and the grains are therefore more or less rounded, but when there is an absence of loamy particles it feels gritty to the touch when rubbed between the fingers, and this constitutes what is called sharpness.

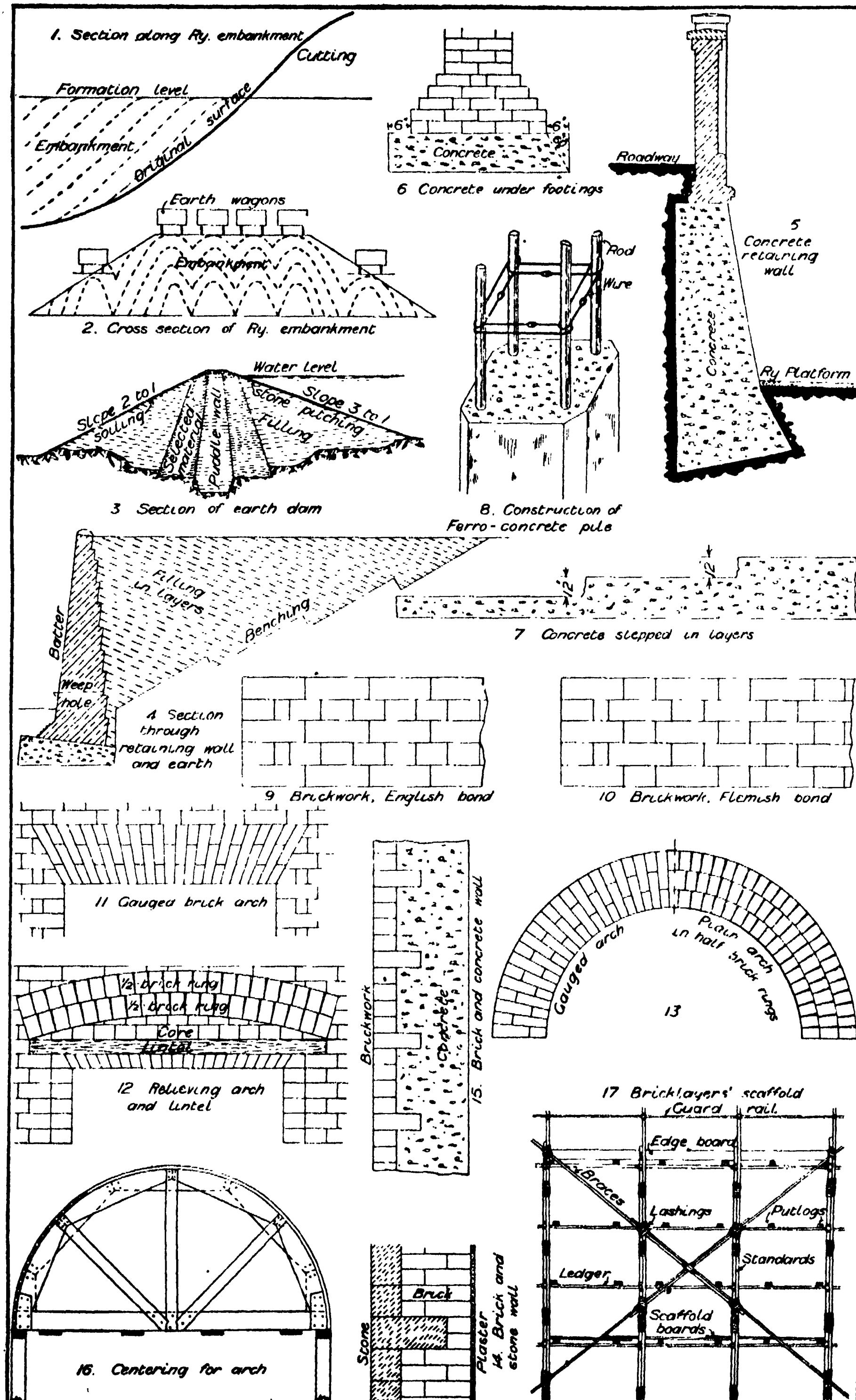
Mixing and Laying. The materials should be mixed on a wooden platform so that the shovels may be used freely without risk of incorporating earthy particles in the mass. They should be thoroughly mixed dry, and then again be well mixed while being watered through a rose, the object being to moisten every particle without washing away any of the cement. As setting takes place very rapidly, not more than half a cubic yard should be mixed at one time and it should be all deposited in place within one hour of mixing. Any disturbance after it has begun to set interferes with the crystallisation and reduces the strength.

It was formerly customary to specify that concrete should be tipped from a height of 10 feet so as to consolidate it; but it is now always deposited as carefully as possible without a drop and then gently rammed with iron beaters; the water should be only sufficient to float in a thin film on the surface. Under the footings of a wall it is generally 9 to 18 in. thick and projects 6 to 9 in. on each side, in order to spread the pressure over a sufficient width of soil to avoid settlement. The minimum amount of concrete under footings is shown in **6**. In the formation of walls it is necessary to confine the material between boarding, the width of the space left fixing the thickness of the wall. To prevent shrinkage, and consequent cracking, the cement should contain no appreciable quantity of free lime, and it should be thoroughly air slaked before use. Machinery is usually employed when large quantities are required, many different forms of steam-driven concrete mixers being in use. Concrete in mass should be deposited in layers not exceeding 12 in. thick, as in **7**, but the work may go on over a large area and even be completed at one part before another is started if it has long steps of 12 in. each.

Ferro-concrete. Ferro-concrete is the name given to a combination of concrete and steel in the form of rods or bars, the concrete taking the compression and the steel the tension. This allows a great reduction to be made in the mass and it is now being largely applied to all kinds of construction, with various modifications in detail. It is, however, necessary to use the very best material and to employ only skilled labour, in order to realise the strength contemplated by the designer. Fig. **8** shows a ferro-concrete pile on the Hennebique system and a similar construction is used for ferro-concrete stanchions. Floors have the steel rods in the lower part of the thickness and carried up over the bearings to resist shear.

Artificial Stone. Artificial stone is a kind of concrete made of Portland cement and granite chippings pressed in zinc-lined moulds to form paving flags, lintels, sills, thresholds, copings, window and door dressings, and moulded ornaments. As soon as the articles can be handled they are removed from the moulds, put in tanks and covered with a solution of silicate of soda for about fourteen days, during which time a chemical change takes place and the resulting material is very hard and non-absorbent, wearing evenly and very slowly. One variety is made from pulverised York stone and put under great pressure. Another is made from sand and chalk lime mixed dry and put into a perforated steel box with a copper lining; a vacuum is created in the box, and boiling water introduced under pressure to slake the lime. Then superheated steam is forced in to complete the slaking, and the whole process is finished in about eight hours.

Concrete Blocks. Concrete blocks may be looked upon as a rough kind of artificial stone. They are formed of ordinary concrete placed in wooden moulds, and are often used in the formation of river walls and sea walls, being used like large blocks of stone. For exposed positions the blocks are larger, and either cramped together or made with grooves, to be filled with pebbles and cement after placing them together. For breakwaters the concrete blocks may reach 100 tons each, or more, in order that they may not be disturbed by the shock of the waves. When the concrete is deposited in mass under water, it is called *béton;* it is then usually rich in cement to allow of some being washed out, and is shot down a trunk, or lowered in skips with movable bottoms, to prevent as much as possible from being carried away.



EARTH, CONCRETE, AND BRICKWORK IN CONSTRUCTION

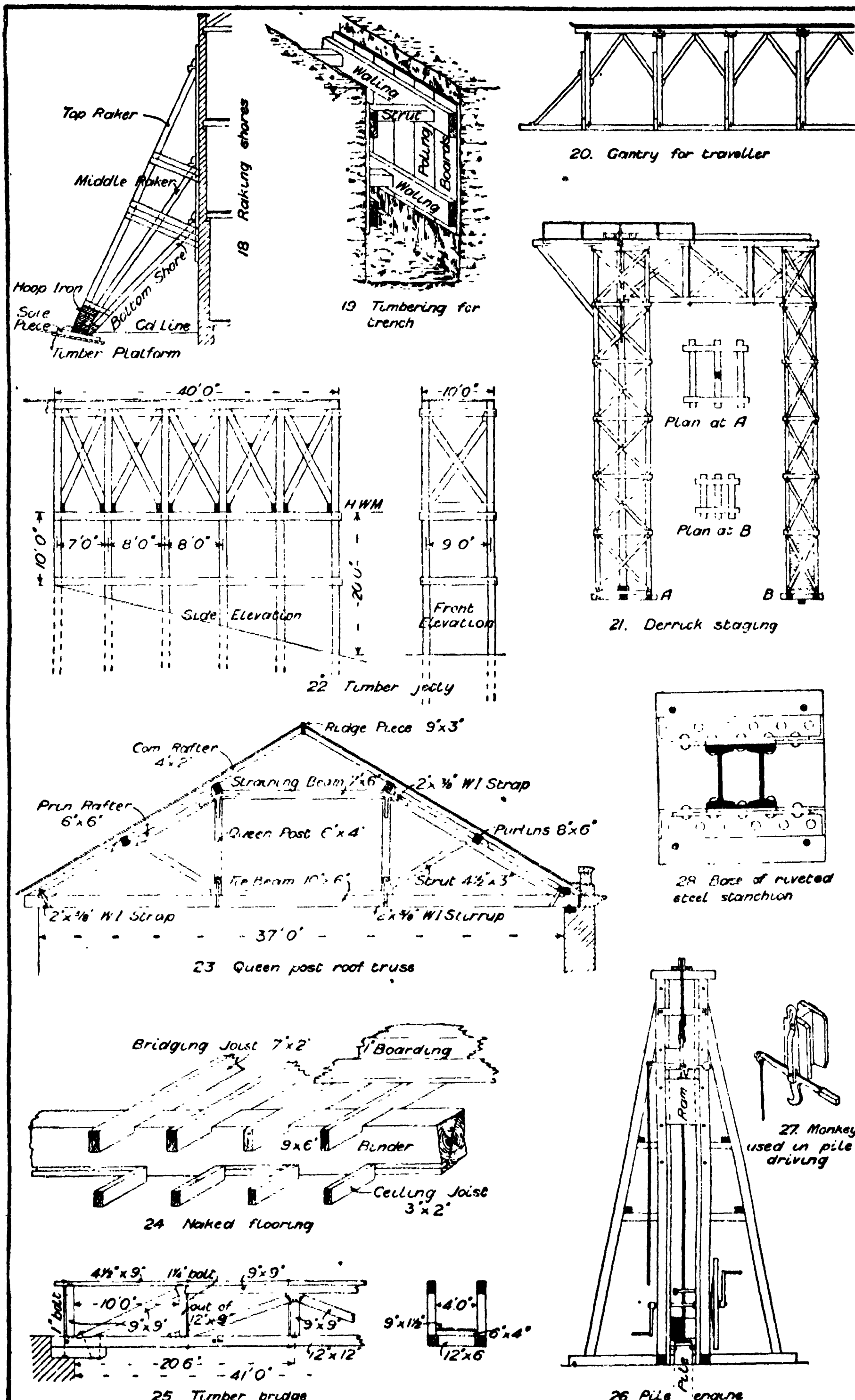
Brickwork. Bricks are small blocks of baked clay, of slightly different sizes in different districts. In London and the South of England they are generally smaller than elsewhere, but including the mortar joints they may be considered as 9 in. long by 4½ in. wide by 3 in. thick. In the Midland and Northern districts the bricks themselves are mostly of the latter size, so that it is sometimes difficult to bond two varieties together. The approximate size has been settled naturally by what is convenient for the bricklayer to handle, and it is suitable for building up structures and openings of useful dimensions. Bricks are connected together by mortar composed of one part of grey stone lime to two parts of clean sharp sand, or, in more important work, by mortar composed of one part of Portland cement to three parts of sand. They are laid so as to break joint with each other and form a bond, or toothing, which strengthens the work and distributes the pressure over a wider area. English bond, as in **9**, is considered to be the strongest, and is used for warehouses and railway work where strength is of more importance than appearance; Flemish bond, as in **10**, is generally used for house building on account of its better appearance. There are several other forms of bond less frequently used.

Bricklaying. In the interior of all walls the bricks are laid as far as possible transversely, with joints running through from face to face, so that the distinctive names apply only to the face work. The base of a wall is always extended by footings, each projecting 2¼ in. on each side, until the bottom width is double the thickness of the wall. The height of any wall should not exceed 16 times its thickness, but generally the thickness is determined by the local bylaws. When openings are formed in walls they may be closed in at the top by lintels or straight beams of concrete, artificial stone, or natural stone, which are usually surmounted by an arch in order to relieve the lintel from pressure. These lintels seldom extend more than 4½ in. in from the face of the wall and gauged arches [**11**] are frequently substituted for them. The remaining thickness of the wall over the opening is generally carried by a relieving arch built in half-brick rings with a core below supported on rolled joists or fir lintels [**12**]. In the latter case the arch extends to each extremity of the timber, so that if it should decay or be burnt out only the core will fall and the brickwork above will remain, supported by the arch. When the opening may be curved on top a brick arch without a lintel is employed, the bricks being either gauged or laid in plain half-brick rings [**13**]. When the available space above the opening is insufficient for an arch, rolled steel joists are used, and they have the advantage of providing a suitable bearing for cross-joists, should such be required.

In gauged work the bricks are cut or rubbed so as to make true surfaces which only require thin joints, say ⅛ in. thick, while in ordinary brickwork the roughness and irregularity of the bricks necessitates a joint at least ¼ in. thick. Brick retaining walls are generally built with a battering face, as in **4**, to throw the centre of gravity well back, and the courses are then built with a slope backwards perpendicular to the direction of the face. The back of the wall may be straight and vertical, or may be stepped to increase the thickness towards the base. A thickness at base of one-fourth the height would be a light wall, and a thickness of one-third the height would be a fairly heavy wall. They are designed according to the pressure likely to be exerted against them by the supported earth, and this again is dependent upon the natural slope of the material, or the slope at which it would permanently remain if exposed to the weather and unsupported. Provision has to be made by weep holes for the escape of any water, which might otherwise tend to accumulate at the back and overturn the wall. Piers need to be very carefully bonded, as they very often have to carry heavy loads. Every joint in a course should be covered by a brick in the courses above and below, or, as it is technically described, no straight joints should occur in the interior of the work.

Masonry. Masonry was formerly divided into brick masonry and stone masonry, the term masonry referring to the building together of separate blocks. A change has been taking place during the last 50 years, and the term masonry now relates only to stone work. Rough stone, as picked up from the surface of the fields in stone districts, may be used without any preparation to form dry stone division walls to the fields, or they may be laid in mortar to form rubble work. The refuse stone from a quarry may be used in a similar way, forming flat-bedded rubble when the stone is laminated, or various forms of polygonal work, random work, or snecked work, when hammer dressed. Rough rubble work is strengthened by being brought up to level courses every two or three feet in height, so that a fresh start may be made at each new level. When each stone is roughly squared, the stability is greatly increased, while in random rubble the strength is practically limited to that of the mortar in which it is bedded. When the squared stone is of large size it is called *block-in-course work*, and this is the best kind of rubble. Some varieties of stone, such as Kentish rag, are so tough that they can be worked only by a hammer and used as rubble, but sandstone and those limestones that come under the designation of freestone can be truly dressed with a chisel to form large blocks of ashlar, and these, when built up, form the strongest kind of work, suitable for public buildings. When a stone is close-grained and can be worked with sharp arrises it is suitable for moulded work, and can then be used for window dressings and architectural work in general. There are many different ways of finishing the face and the edges, according to the nature of the stone and the taste of the architect.

In the construction of lighthouses not only the hardest stone, such as granite, has to be used, but the blocks have to be very truly dressed and dovetailed together, with cramps between the



THE USE OF TIMBER IN CONSTRUCTION

courses. Masonry dams for water reservoirs also require very careful dressing and bedding to ensure the greatest strength with the smallest quantity of material. With laminated stone it is necessary to place the blocks so that the natural bed is perpendicular to the pressure. The laminations will therefore be horizontal in a wall, and radial in an arch; but in an undercut cornice the laminations are vertical, running from front to back, to avoid the risk of pieces dropping off. Hard stone resists the action of the weather very considerably, but under the action of fire is far less resisting than common brickwork. Owing to the cost of stone in some districts walls are built of brickwork and only faced with stone, as shown in **14**. In these cases it is necessary to bond the two materials together by limiting the height of the stone to so many courses of brickwork, and building some stones further in; or cramps may be used to connect the two at short intervals. In a somewhat similar manner walls are sometimes built of concrete and faced with brickwork, as in **15**. Generally, the chief material used in building depends upon what is most readily obtained in the district.

Timber. Timber in constructive work is mostly used for temporary purposes, as for centering to support arches during construction [**16**], scaffolding [**17**], stagings, shoring, and struttings [**18**], supporting the sides of excavations [**19**], gantries [**20**], derrick stages [**21**], etc. In permanent work it is used for gantries in stone-yards, jetties [**22**], roofs [**23**], and floors [**24**]. Where timber is plentiful and other material is scarce, it is used for bridges [**25**], and for complete buildings. There are a few important principles to bear in mind, as laid down by Professor Rankine—

1. To cut the joints and arrange the fastenings so as to weaken the pieces of timber that they connect as little as possible.

2. To place each abutting surface in a joint as nearly as possible perpendicular to the pressure which it has to transmit.

3. To proportion the area of each surface to the pressure which it has to bear, so that the timber may be safe against injury under the heaviest load which occurs in practice, and to form and fit every pair of such surfaces accurately in order to distribute the stress uniformly.

4. To proportion the fastenings so that they may be of equal strength with the pieces which they connect.

5. To place the fastenings in each piece of timber so that there shall be sufficient resistance to the giving way of the joint by the fastenings shearing, or crushing their way through the timber.

To these may be added a sixth principle not less important than the foregoing—*viz.*: To select the simplest forms of joints, and to obtain the smallest possible number of abutments.

In framing structures, the chief point is to see that they are properly braced by diagonal struts to prevent racking movements caused by wind or other side pressures.

Timber piling is much used in riverside work. Whole timbers from 10 to 14 in. square are preferred for this work, pointed and shod with iron, and hooped at the top to prevent splitting while being driven. A ram, weighing from 5 to 30 cwt., is raised by a pile engine [**26**] and released by the use of a trip lever, or monkey [**27**], when it reaches the top, so as to give a heavy blow on the head of the pile, and this is repeated until the set or distance driven by the last blow does not exceed ½ in. Piles, properly driven, will usually support a load of 1 ton per inch width of side in firm ground, or 5 tons per square foot of cross section in soft ground.

Iron. Iron is the generic term for three classes of material—wrought iron, mild steel, and cast iron. These differ in composition, chiefly in the proportion of carbon combined with the iron, but this trifling difference has a remarkable influence upon the properties of each. Wrought iron with ¼ per cent. of carbon is tough, fibrous, ductile, and can be forged and welded. Mild steel, with ½ to 1 per cent. of carbon, is tougher, more homogeneous in structure, somewhat ductile, and, with care, can be both forged and welded. Cast iron, with 2 to 5 per cent. of carbon, is crystalline, brittle, cannot be forged or welded, but may be cast in various shapes by melting and pouring into a mould. As may be gathered from the properties, wrought iron is used where the piece is required to resist tension, or cross strain, or where it has to be rolled or forged into shape, or welded to connect it with other pieces. Mild steel is used for similar purposes where greater strength is required. It is mostly found in the form of rolled joists, angles, bars, and plates, and used for the construction of girders, roofs, bridges, cranes, boilers, etc. Cast iron is very strong in compression, but weak in tension, and is therefore used where its particular properties render it specially useful, as for castings, brackets, machinery framings, columns, and stanchions. The latter, being subject to direct loading, are in simple compression, but when the ratio of length to least diameter exceeds about 26, cast iron shows a tendency to bend, and then wrought iron or mild steel are more appropriate.

Bolts and Rivets. These have been called the *stitches* by which ironwork is connected. The bolts being easily removable, may be likened to chain-stitch; and rivets, having to be cut out individually to remove them, are typical of the lock-stitch. Bolts are used for connecting cast-iron work, because the material will not stand the blows necessary in riveting. They are also used in wrought iron and steel work where connections have to be made on the ground during erection, to avoid the fire risks from having a rivet forge on an unfinished building, and to avoid the expense of engaging skilled men to put in a few field-rivets, as they are called. Rivets are specially used in the permanent connection of wrought iron and steel work; they bind the parts closely together, rendering the construction stiff and rigid, and permitting a proper distribution of stress through the various members. Fig. **28** shows the plan of base of a riveted steel stanchion.

HENRY ADAMS

A Biographical and Critical Survey of the Poets of Last Century before Tennyson, and the Influences on Their Work.

NINETEENTH CENTURY POETRY

THE poetry of the nineteenth century has its roots in the work of the eighteenth century. Its branches stretch forward into the century that is yet in its infancy. In its style, a notable characteristic is a certain reaction against artificiality and mere rhetoric. In the spirit of it is distinguishable the influence of the Germany of Goethe and Schiller; of the France of Rousseau and Victor Hugo; and of the "problem" writers of Norway and Denmark. The movements toward political freedom in France, Italy, and Greece, and the evolution of English democracy, have all affected it vitally. Thus, to its understanding must be brought some knowledge of the historic happenings amid which it arose and flourished.

It is possible to take the works of two or more of the greatest poets of the period, and to derive pleasure from the isolated perusal of them. But while there is much to be said for the study of the poetry of any writer for its own sake, too general a neglect of "books about books" is certainly to be avoided. The more we know of the main facts in the life and times of a great writer, the better shall we understand and appreciate what he has written. It is "the man behind the book" we are interested in, as Carlyle pointed out. So far as the poets and poetry of the nineteenth century are concerned, there is no lack of adequate guidance. The field is a wide one, and its flowers and fruits are varied. In all, something like two hundred names claim consideration. Of these, however, three or four are of outstanding importance; and rather less than thirty need engage those to whom poetry does not make a very strong appeal. Before taking up the study of any one of these writers, the reader could hardly do better than glance at the names in such a series as the "English Men of Letters," and, selecting the monograph dealing with the author he purposes taking up, make this the groundwork or starting-point of the study proper.

GEORGE CRABBE (b. 1754; d. 1832) is a particularly interesting figure. In his verse, says Canon Ainger, "pity appears, after a long oblivion, as the true antidote to sentimentalism. The reader is not put off with pretty imaginings, but is led up to the object which the poet would show him, and made to feel its horror." The horror Crabbe chose to describe was that of the sordid side of English village life as he witnessed it in his native Suffolk.

He applied the lash to the ignoble rich as well as depicted with graphic realism the lot of the ignorant poor. We read Crabbe for what he says more than because of his style, which is unequal and frequently faulty. His knowledge of humanity is extensive; but he lacks both fancy and a sense of humour.

WILLIAM GIFFORD (b. 1756; d. 1826) was a shoemaker's apprentice. A giant, he used his strength like a giant. His two satirical poems, "The Baviad" and "The Mæviad," crushed out of existence the insipid poetry of the so-called "Della Cruscan School"; and to him is generally, but erroneously, attributed the "Quarterly Review's" famous (or infamous) attack on Keats's "Endymion," which was the work of J. W. Croker. He translated "Juvenal" and edited some of the old dramatists.

WILLIAM BLAKE (b. 1757; d. 1827) is a link between the Elizabethans and Wordsworth. His love of children speaks to us in his "Songs of Innocence"; his feelings of horror at the bitter side of life in his "Songs of Experience." He was a mystic, with something of the contrast of simplicity and subtlety in his work that is characteristic of Browning's poems; and he felt keenly and expressed keenly social wrongs and ecclesiastical tyranny. Like Crabbe, he had to fight poverty, and owed his knowledge to his own efforts toward self-improvement. Like Crabbe, he is again becoming read; but perhaps his fame rests mainly upon his skill as an artist.

SAMUEL ROGERS (b. 1763; d. 1855), that "grim old *dilettante*, full of sardonic sense," as Carlyle called him, wrote a long poem in heroic metre on "The Pleasures of Memory," and caught, in his blank verse

poem "Italy," some of the beauties of that Southern land. He had the wisdom to decline the Laureateship. ROBERT BLOOMFIELD (b. 1766; d. 1823), first a rural "hand" and then a shoemaker, wrote, in a London garret, "The Farmer's Boy," which gives a sympathetic view of the life indicated by its title. He derived his style from Thomson's "Seasons." Another poet of Nature and the poor, though on a much higher level, is JAMES HOGG (b. 1770; d. 1835), the "Ettrick Shepherd," who stands next to Burns in the order of Scotland's peasant-poets. He described himself to Scott, to whom he sent contributions for the latter's "Border Minstrelsy," as "King of the Mountain and Fairy School of Poetry," and this piece of self-description is accepted by the critics. "When the Kye Come Hame" and "Kilmeny" (the last-named from "The Queen's Wake," a series of legendary tales and ballads supposed to have been sung by the Royal bards at Holyrood) are among Hogg's most popular, and deservedly popular, compositions.

Wordsworth's Life. WILLIAM WORDSWORTH (b. 1770; d. 1850) is one of the greatest poets of the nineteenth century. Indeed, his influence, which was of slow growth at the outset, is growing yet. In his early days he was greatly influenced by the ideals of French Republicanism and the teaching of William Godwin, the author of "Political Justice," a work basing morals on necessity, who also had a marked influence on Coleridge. When France, having first debased them, forsook her humanistic ideals for dreams of world conquest under Napoleon, the effect on Wordsworth would have been disastrous but for the devotion of his sister Dorothy and the fact that a legacy of £900 left to the brother and a sum of £100 bequeathed to the sister enabled them to settle down quietly, first at Racedown, in Dorset—where Wordsworth's one tragedy, "The Borderers," was written—then at Alfoxden, by the Quantock hills—which district inspired his and Coleridge's contributions to the volume of "Lyrical Ballads"—and, finally, at Grasmere. This was the home of the Wordsworths from 1799 till the poet's death, the three places of residence there being Dove Cottage, Allan Bank, and Rydal Mount. "The Prelude; or, the Growth of a Poet's Mind," an autobiographical poem in blank verse, reflects the influence of Continental travel—Wordsworth visited Germany, Italy, and Switzerland as well as France—and the philosophical views of Godwin. That poem and "The Excursion" are parts of an uncompleted scheme.

Wordsworth as a Critic. Wordsworth has to be considered in three aspects—as a critic, as a teacher, and as a poet. His critical opinions may be studied in the preface and appendix to the "Lyrical Ballads," the preface to "The Excursion," and in numerous letters. In the preface to the "Lyrical Ballads" he writes as follows: "It may be safely affirmed that there neither is, nor can be, any essential difference between the language of prose and metrical composition. We are fond of tracing the resemblance between poetry and painting, and accordingly we call them sisters; but where shall we find bonds of connection sufficiently strict to typify the affinity betwixt metrical and prose composition? They both speak by and to the same organs; the bodies in which both of them are clothed may be said to be of the same substance, their affections are kindred and almost identical, not necessarily differing even in degree." Pursuing the same idea, he writes in the appendix to the "Lyrical Ballads" that "metre is but adventitious to composition," and that "the phraseology for which that passport is necessary, even where it may be graceful at all, will be little valued by the judicious."

The best proof of the error inherent in this view of poetry is to be found in Wordsworth's own work. Elsewhere, in his intense scorn for the artificial and the meretricious, which were so characteristic of much of the poetry of the eighteenth century, Wordsworth went to the verge of the trivial. But though he raised a storm of criticism, which delayed due recognition of his surpassing genius and is not yet exhausted, it is well to remember with Coleridge, one of the greatest of literary critics, especially where Wordsworth is concerned, that but for the prefaces and appendices much of what has been said against Wordsworth's poems would be reduced to absurdity. The few pages that gave such an opportunity to the pungent parodists of "Rejected Addresses," to Byron, to Leigh Hunt, to Jeffrey, and to others who poured scorn on Wordsworth, would, but for the fear that they represented an intention to overthrow the accepted canons of art, have been "passed over in silence as so much blank paper, or leaves of a bookseller's catalogue," and "only regarded as so many light or inferior coins in a rouleau of gold."

The Teaching of Wordsworth. As a teacher Wordsworth expressed his purpose to be: "To console the afflicted, to add sunshine to daylight by making the happy happier, to teach the young and the gracious of every age to see, to think, and feel, and, therefore, to become more actively and securely virtuous." It will be seen from this he took his vocation seriously. "The poet," he averred, "is a teacher. I wish to be considered as a teacher or as nothing." What did he teach?

George Brimley, in one of the most brilliant of his essays, written in 1851 and still applicable, contends, with reason, that the value of Wordsworth's teaching "lay mainly in the power that was given him of unfolding the glory and the beauty of the material world and in bringing consciously before the minds of men the high moral function that belonged in the human economy to the imagination, and in thereby redeeming the faculties of sense from the comparatively low and servile office of ministering merely to the animal pleasures. . . . He has shown the possibility of combining a state of vivid enjoyment, even of intense passion, with the activity of thought and the repose of contemplation. He has, moreover, done more than any poet of his age to break down and

obliterate the conventional barriers that, in our disordered social state, divide rich and poor into two hostile nations; and he has done this, not by bitter and passionate declamations on the injustices and vices of the rich, and on the wrongs and virtues of the poor, but by fixing his imagination on the elemental feelings, which are the same in all classes, and drawing out the beauty that lies in all that is truly natural in human life."

The Poetry of Wordsworth. Was Wordsworth a poet? Indubitably: as Plato and Dante were poets. None but a great poet could have written such lines as these from the poem "Composed a few miles above Tintern Abbey," in 1798:

"For I have learned
To look on Nature, not as in the hour
Of thoughtless youth; but hearing oftentimes
The still, sad music of humanity,
Nor harsh, nor grating, though of ample power
To chasten and subdue. And I have felt
A presence that disturbs me with the joy
Of elevated thoughts; a sense sublime
Of something far more deeply interfused,
Whose dwelling is the light of setting suns,
And the round ocean, and the living air,
And the blue sky, and in the mind of man:
A motion and a spirit, that impels
All thinking things, all objects of all thought,
And rolls through all things."

Let the student who seeks to find Wordsworth at his best also ponder the exquisite ode entitled "Intimations of Immortality from Recollections of Early Childhood." But Wordsworth's claim to rank among the immortals might be based on his sonnets alone. From whatever standpoint it may be looked at, the sonnet "Composed upon Westminster Bridge, September 3rd, 1802," is one of the finest in the language:

"Earth has not anything to show more fair.
Dull would he be of soul who could pass by
A sight so touching in its majesty.
This city now doth, like a garment, wear
The beauty of the morning; silent, bare,
Ships, towers, domes, theatres, and temples lie
Open unto the fields, and to the sky,
All bright and glittering in the smokeless air.

"Never did sun more beautifully steep
In its first splendour, valley, rock, or hill;
Ne'er saw I, never felt, a calm so deep!
The river glideth at his own sweet will.
Dear God! the very houses seem asleep;
And all that mighty heart is lying still!"

There is nothing in the Elizabethan writers of the sonnet to surpass this in perfection of form. Tennyson never wrote more truly nor with finer insight than when, in Wordsworthian phrase, he declared that the Laureate's wreath came to him—

"Greener from the brows
Of him who uttered nothing base."

It is unnecessary to urge Wordsworth upon the attention of the general reader, for he is so securely a popular classic that his poetry is in no danger of neglect.

Coleridge. Chief of Wordsworth's contemporaries was SAMUEL TAYLOR COLERIDGE (b. 1772; d. 1834). Coleridge was a talker, a preacher, a philosopher, and a mystic. His best work belongs to his early years, when he was inspired by his love of Nature and by the revolutionary idealism of France, and when, with Southey and Robert Lovell, he planned the foundation of a Utopia "in the rich heart of the West." Unhappily, all through his life, plans came more easily to him than performance. His life story is one of the saddest in English literary history. His health was poor, and his habits were worse. It is a notable fact that his ballad epic of "Christabel," though a fragment, exerted in MS. form, some twenty years before it was published, a wonderful influence on Scott and other contemporary English poets. "In this weirdly beautiful creation," says one critic, "the spiritual and material are so exquisitely blended that it is difficult to know where they run into each other."

For an explanation of the dreamland beauty of "Christabel" and the "Rime of the Ancient Mariner" recourse must be had to the German philosophers, particularly to Goethe, Herder, Schelling, and others of their school, to whom Coleridge was much indebted. Mr. Swinburne says of "The Ancient Mariner" that it is "perhaps the most wonderful of all poems. In reading it we seem rapt into that paradise revealed by Swedenborg, where music and colour and perfume were one, where you could hear the hues and see the harmonies of heaven. For absolute melody and splendour it were hardly rash to call it the first poem in the language." Mr. William Watson has suggested the atmosphere of the poet in the phrase "the wizard twilight Coleridge knew."

Sir Walter Scott. Sir WALTER SCOTT (b. 1771; d. 1832) is essentially a poet for the young. Repelled by the Revolution from visions of the future, he sought and restored to letters the romance of the past. "The Lay of the Last Minstrel," "Marmion," and "The Lady of the Lake," his best poems, are for the million what "Christabel" and "The Ancient Mariner" are for the comparatively few. For pure joy in nature and love of humanity Scott was not excelled by either Wordsworth or Coleridge, though there is a certain mechanical touch in his verse and a mannerism which prevent its being classed with the greatest English poetry.

Another Scots poet, and one of the sweetest of song-writers, was ROBERT TANNAHILL (b. 1774; d. 1810), a Paisley weaver, whose life was sad and ended tragically. His "Braes o' Gleniffer" and "Jessie, the Flower o' Dunblane" are favourite lyrics with Scotsmen the world over.

Southey and Landor. ROBERT SOUTHEY (b. 1774; d. 1843), as a poet, is little honoured today, though Mr. Saintsbury boldly champions his cause. His change from a democratic to a Tory standpoint (exemplified in the difference between "Wat Tyler" and "The Vision of Judgment") may have had some influence on popular taste; but his choice of subjects and

his ponderous treatment are sufficient reasons for neglect. Of his longer works, "Roderick, the Last of the Goths" is the best. The others are "Thalaba, the Destroyer," a rhymed epic of Arabia; "Madoc," a semi-historical poem, descriptive of the adventures of a Welsh prince; and "The Curse of Kehama," a poem in irregular rhymes, the theme of which is drawn from Hindu mythology. Southey will always be kept in sure if slender memory by such spirited ballads as "The Battle of Blenheim," "The Well of St. Keyne," and "The Inchcape Rock."

The name of WALTER SAVAGE LANDOR (b. 1775; d. 1864) recalls one of the most touching stories in the romance of reality. It is told with exquisite sympathy by Sir William Hunter in the introductory chapter of his "Thackerays in India." Midway in the impetuous rush of his stormy youth Landor found kindness in the family of Lord Aylmer, with whose gifted daughter Rose he fell in love. The affection was mutual. It was Rose Aylmer who lent him the book that inspired the work—"Gebir"—in which his genius first flashed out into enduring flame. Hope told a flattering tale, and then Rose Aylmer was sent out to relatives in Calcutta, there to find an early grave. For days and nights her image never left Landor's brain. "During hours of sleeplessness he wrote the elegy which enshrines in a casket of pearl the name of Rose Aylmer as long as maiden hearts shall ache and the English language endure":

> "Ah, what avails the sceptred race?
>   Ah, what the form divine?
> What every virtue, every grace?
>   Rose Aylmer, all were thine.
> Rose Aylmer, whom these wakeful eyes
>   May weep but never see,
> A night of memories and of sighs
>   I consecrate to thee."

Landor gave a marked impetus to the Romantic movement, and, while he is more for the student than for the general reader, the latter must make some acquaintance with his poetry and his prose. The poems of CHARLES LAMB (b. 1775; d. 1834) are chiefly valuable as expressions of his gentle nature.

Campbell and Moore. THOMAS CAMPBELL (b. 1777; d. 1844) is, like Southey, best remembered by his lyrical poems—"Hohenlinden," "Ye Mariners of England," "The Soldier's Dream," "Lord Ullin's Daughter" and the "Song of the Evening Star" are among them. His "Pleasures of Hope" is an echo of Thomson and Gray. THOMAS MOORE (b. 1779; d. 1852), who wrote "Lalla Rookh" and many songs to old Irish airs, had in abundance the double gift of vocal and poetic melody. His poetry, said Jeffrey, was as the thornless rose; "its touch of velvet, its hue vermilion, and its graceful form cast in beauty's mould." "To me," said Byron, "some of Moore's last Erin sparks—'As a Beam o'er the Face of the Waters,' 'When he who Adores thee,' 'Oh, Blame not the Bard,' 'Oh, Breathe not his Name'—are worth all the epics that ever were composed."

But Moore possesses claims in addition to those dependent on the charm of his "Irish Melodies." His latest critic, Mr. Stephen Gwynn, remarking on the increasing virtuosity shown during the nineteenth century in the management of lyric metres, says: "From Cowper and Crabbe to Mr. Swinburne is a strange distance; and it has not been sufficiently realised that Moore is very largely responsible for the advance. Many critics have noted the change from the strictly syllabic scansion of Pope's school to metres like those of Tennyson's 'Maud,' and a hundred later poems, in which syllabic measurement is wholly discarded. It has been noted also that, even in the freer metres of the sixteenth and seventeenth centuries, lyric writers confined themselves to variations of the trochee or iambic, and that an anapæstic or dactylic measure is hardly found before Waller. But it has been hardly recognised that till Moore began to use these triple feet no poet used them with dexterity and confidence. . . . It is Moore's great distinction that he brought into English verse something of the variety and multiplicity of musical rhythms."

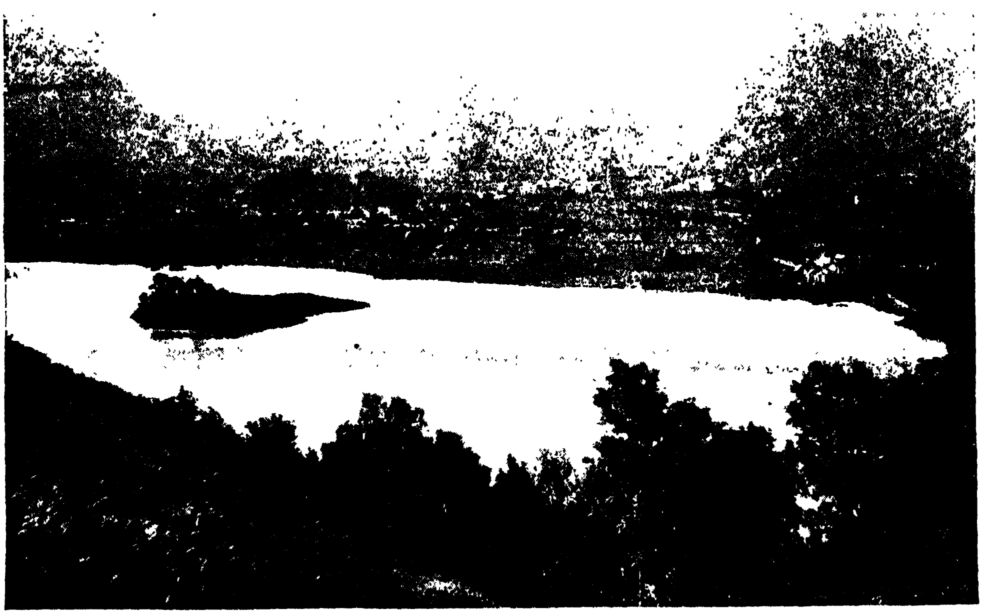
Other Contemporaries of Wordsworth. Other poets calling for brief mention are: EBENEZER ELLIOTT (b. 1781; d. 1849), whose "Corn Law Rhymes" have served to distract attention from his transcripts from Nature; LEIGH HUNT (b. 1784; d. 1859), whose reputation, largely due to his prose writings, would not be inconsiderable were it based only on "The Story of Rimini," and his other and shorter poems, of which "Abou Ben Adhem" and "Jenny Kissed Me" are most familiar; THOMAS LOVE PEACOCK (b. 1785; d. 1866), who wrote a number of delightful lyrics which are to be found in his novels; and BRYAN WALLER PROCTER ("Barry Cornwall") (b. 1787; d. 1874), who, while he is better known for his appreciations of poetry than as a poet himself, wrote at least one good song, "The Sea."

Byron. LORD BYRON (b. 1788; d. 1824) has been strongly commended to working-class readers by no less an authority than Viscount (John) Morley. Since the reaction following the somewhat flattering hero-worship to which he was once subjected, Byron has enjoyed a far greater popularity on the Continent than in England. It is especially true of Byron that without some knowledge of the successive stages of his short but crowded life, his belongings, his surroundings, his friendships, and his fortunes, a great deal of his poetry, as one of his editors, Mr. Ernest Hartley Coleridge, points out, lacks significance. His output was large. It comprises two epics, or quasi-epics, "Childe Harold" and "Don Juan"—which constitute his best work—twelve narrative poems, eight dramas, seven or eight satires, and a multitude of occasional poems, lyrics, epigrams, and jeux d'esprit. As to the dramas, Mr. Coleridge, who reminds us that "Werner" was the only one that took any hold on the stage, considers "Sardanapalus" "by far the greatest and most original" of the "regular" plays. The

importance of Byron is well expressed by the same critic: "He brings the wisdom of the many to bear upon his individual experience, 'touching it with emotion,' and re-making it by the potency of his wit. His wisdom is not that of the market, nor of the cloister, nor of the academy, but of a man of the world who has realised and faced the problems of existence. If he 'taught' us little of the spiritual amenities of the soul, he has taught us the limitations of our hopes and fears, and to bear with reverence and submission the burden and the mystery of our fate. He is neither pessimist nor optimist, but he reasons concerning things as they are, and the judgment which is come already." He shows, in short, how hollow are many of the baubles for which a section of democracy craves. He is a keen satirist and a humorist "of the following of Rabelais and Sterne." Coleridge has described him as "the parent of modern fun."

According to Dr. Brandes, "French Romanticism and German Liberalism are both direct descendants of Byron's Naturalism." The vogue of Byron's verse-romances induced Scott to turn to prose. "With Byron," says Mr. Gosse, "the last rags of the artificiality which had bound European expression for a century and a half were torn off and flung to the winds. He taught roughly, melodramatically, inconsistently, but he taught a lesson of force and vitality. He was full of technical faults, drynesses, flatnesses; he lacked the power to finish; he offended by a hundred careless impertinences; but his whole being was an altar on which the flame of personal genius flared like a conflagration." In a word, Byron had the true poetic "glamour"; a personality not to be shackled by any laws of rhythm or rhyme. No reader with any taste for poetry, responsive to the passionate expression of a soul unrestful, will need to be urged to the reading of Byron: once taken up, his poetry has a compelling force unsurpassed, if not unrivalled, by that of any other writer of the century.

Shelley. In the case of PERCY BYSSHE SHELLEY (b. 1792; d. 1822), the student of poetry must be warned against being misled by warped and narrow views concerning Shelley's life. Shelley was, as Byron was, a herald of revolt; but he was also, what Byron could hardly be said to be, an idealist. Byron was at times sincere; Shelley always so. If Shelley erred, as we may think, against the social conventions, it was not out of contempt nor in any spirit of reckless libertinism, but because he had constructed for himself a philosophy and adhered to it. His principal works are "Queen Mab," "Alastor," "The Revolt of Islam," "Prometheus Unbound," "The Cenci," "Julian and Maddalo," the "Witch of Atlas," "Epipsychidion," "Adonaïs," and "Hellas." In "Queen Mab" were expressed the mingled idealism and atheism of the Revolution. "Prometheus Unbound"



THE BEAUTIFUL SCENERY AT GRASMERE IN THE MIDST OF WHICH WORDSWORTH LIVED

is well described as "the finest example we have of the working out in poetry of the idea of a regenerated universe." "Adonaïs" was a lament for the death of John Keats. "The Cenci" is the most powerful drama in English since Otway's "Venice Preserved." Shelley's was a divided personality: he lived in the world, but all his thoughts soared into the empyrean. As a poet of the imagination, he was immeasurably superior to Byron. Of his lyrics, the "Ode to the West Wind" is as imperishable as anything in English poetry. "At his best," says Mr. Gosse, "Shelley seems like Æschylus, and, at his worst, merely like Akenside."

Keats. To turn from Byron and Shelley to JOHN KEATS (b. 1795; d. 1821) is like passing from a storm in which body and soul have been engaged to some sweet resting-place. Keats leaves the problems of passion—whether physical or purely intellectual—alone, and tunes his lyre to hymns of beauty and the praise of Nature. He is one of the first of modern literary poets, drawing his inspiration largely from Ancient Greece and Elizabethan England, though the influence of his friendship for Leigh Hunt is distinguishable in his early poems. "Keats," writes Mr. Gosse, "has been the master-spirit in the evolution of Victorian poetry. Both Tennyson and Browning, having in childhood been enchained by Byron, and then in adolescence by Shelley, reached manhood only to transfer their allegiance to Keats, whose influence on English poetry since 1830 has been not less universal than that of Byron on the literature of the Continent. . . . In spite of what he owes to the Italians . . . no poet, save Shakespeare himself, is more English than Keats; none presents to us, in the harmony of his verse, his personal characters, his letters, and his general tradition, a figure more completely attractive nor better calculated to fire the dreams of a generous successor."

When the critics attacked "Endymion," the attack was meant to reach, through that poem, the detested politics of Leigh Hunt. Not only Browning and Tennyson, but Dante Gabriel Rossetti, William Morris, and Algernon Charles Swinburne owe much to Keats. "Hyperion" is a beautiful fragment; the odes "On a Grecian Urn" and "To a Nightingale," the sonnet, "On first Looking into Chapman's Homer," and the poems, "The Eve of St. Agnes" and "La Belle Dame Sans Merci," stand by themselves in the foremost ranks of their kind. They are the work, be it remembered, of one whose father worked in a livery stable, and who began life as a surgeon's apprentice.

Other Poets of the Early Nineteenth Century. There are many names to be mentioned before we come to the next one of outstanding importance. Among them are Sir AUBREY DE VERE (b. 1788; d. 1846), who went to school with Byron, was a friend of Wordsworth's, and wrote several fine sonnets and two dramas of much poetic strength, "Julian the Apostate" and "Mary Tudor"; JOHN CLARE (b. 1793; d. 1864), who was the son of a poor labourer, and whose "Poems Descriptive of Rural Life" owed much, as Bloomfield's did, to the influence of Thomson's "Seasons"; HARTLEY COLERIDGE (b. 1796; d. 1849), eldest son of Samuel Taylor Coleridge, and a sonneteer of much felicity and gracefulness; GEORGE DARLEY (b. 1795; d. 1846), critic, and author of a pastoral, "Sylvia," and a poem, "Nepenthe," in which, amidst much gorgeous imagery, he worked forward to the apotheosis of Contentment; and WILLIAM MOTHERWELL (b. 1797; d. 1835), a Scots song-writer, whose "Jeanie Morrison" and "My Head is like to Rend, Willie," are classic north of the Tweed.

One of the most popular poets of this period was THOMAS HOOD (b. 1799; d. 1845), whose "I remember, I remember," "The Dream of Eugene Aram," "The Song of the Shirt," and "The Bridge of Sighs" are as truly poetry of the heart as his inimitable humour was original.

Poets Passing and Lasting. Others are WILLIAM THOM (b. 1798; d. 1848), a Scots hand-loom weaver, and author of a remarkable poem, "The Mitherless Bairn"; Lord MACAULAY (b. 1800; d. 1859), whose "Lays of Ancient Rome" call for mention here; Sir HENRY TAYLOR (b. 1800; d. 1886), whose "Philip van Artevelde" is to be commended as a study in human history as well as an experiment in romantic (literary) drama; CHARLES J. WELLS (b. 1799; d. 1879), the friend of Keats, and the beauties of whose "Joseph and His Brethren," a Biblical drama, were neglected till attention was drawn to them by Mr. Swinburne; WILLIAM BARNES (b. 1801; d. 1886), the pastoral poet of Dorsetshire; WINTHROP MACKWORTH PRAED (b. 1802; d. 1839), a writer of bright, witty "society verse"; RICHARD HENRY HORNE (b. 1803; d. 1884), whose fine epic "Orion," was sold first at one farthing per copy, "as a sarcasm upon the low estimation into which epic poetry had fallen"; THOMAS LOVELL BEDDOES (b. 1803; d. 1849), an introspective poet, whose "Death's Jest Book; or, the Fool's Tragedy," proclaims him a good poet if a poor dramatist; and ROBERT STEPHEN HAWKER (b. 1803; d. 1875), the inspired poet-priest of Morwenstow.

Our Greatest Poetess. ELIZABETH BARRETT (BROWNING) (b. 1806; d. 1861), England's greatest poetess, whose "Cry of the Children," "Casa Guidi Windows," "Poems Before Congress," "Aurora Leigh," and "Sonnets from the Portuguese" bespeak the exquisite tenderness of a womanly woman more than they display the technical excellence of a poet. Finally, we must mention JOHN STERLING (b. 1806; d. 1844), whose life—it is enshrined in Carlyle's splendid memoir—is his best poem; and RICHARD CHENEVIX TRENCH (b. 1807; d. 1886), a writer of some sincere and simple poetry, a noteworthy divine, and a philologist of some distinction.

Every poet named in this group is of some importance to the student, but with the exceptions of Hood, Macaulay, Praed, and Elizabeth Barrett Browning the general reader need not be expected to have more than a partial knowledge of their writings.

J. A. HAMMERTON

Positions in the Metropolitan and Provincial Police Forces. Royal Irish Constabulary. Fire Brigades.

POLICE AND FIREMEN

Many of the municipal civil servants whose callings we have discussed are but little known, even by name, to the general public whom they serve. Unlike these, however, the police officer does his duty under the eye of the people.

In a work like the present, addressed very largely to students and to young men who have not yet definitely chosen their calling, special importance naturally attaches to the conditions of entry into the service. We shall therefore seek to show the prospective police officer very clearly what physical and other qualifications are requisite for candidates, and what steps should be taken in order to gain admittance. Other leading features will be the duties and rates of pay in the various grades, the prospects of promotion, and finally the terms on which pensions are granted.

Numbers and Constitution. The police forces of the United Kingdom number in all some 68,000 men—a civil army fully as numerous as the medley of British, Belgian, and Hanoverian troops who lined the ridges of Waterloo. Of these officers 51,000 are stationed in England and Wales, and between 11,000 and 12,000 in Ireland. We have termed the police a municipal body, and in the main that description is accurate. If we exclude Ireland, and that part of London which lies outside the City proper, every police force in the kingdom is under the control of a local authority. They comprise two great divisions—the county and the borough constabulary, the former being controlled by a standing joint committee of the quarter sessions and the County Council, the latter by a special committee—the Watch Committee—of the Borough Council. In the City of London, however, the Court of Common Council instead of the Watch Committee is the police authority.

To the general rule of municipal control there are but three exceptions. They are very notable ones, consisting of the largest civil forces in the kingdom—the Metropolitan and Dublin Police, and the Royal Irish Constabulary. The first, although paid largely from municipal sources, is naturally, as the civil power for the capital of the Empire, controlled by the Home Secretary. The Dublin Police owe allegiance to the Chief Secretary for Ireland. The third body—doubtless for old-time political reasons—is under the direction of the Lord-Lieutenant of Ireland. Nevertheless, as the police organisation throughout the country is nearly uniform, it is expedient to include these three Imperial forces among their many municipal brethren, so that our police service may be considered as a whole, and within the scope of a single chapter. But only in one respect is there absolute uniformity among the many police forces of England and Wales. By a statute passed in 1910, every police officer is entitled, except in time of emergency, to one day's rest weekly.

On such questions as the age and height of candidates and the rates of pay for officers of each grade, no fixed scale is operative, each local authority being empowered—within certain limits—to fix the standard for its own force.

The Metropolitan Police Force. For the most part these differences are but slight, and therefore we treat our composite subject by selecting as typical that largest of all police bodies—the Metropolitan Police Force, distinguishing where necessary between its regulations and those of the City Police and the numerous county and borough forces. The Royal Irish Constabulary, however, as a semi-military body with a special organisation of its own, is separately considered.

The Metropolitan Police Force, to which is entrusted the unique task of safeguarding the citizens of Greater London, has an area of 700 square miles under its surveillance. As an Imperial force it also furnishes men for duty at the Royal palaces, chief naval bases, and War Office factories and stores. Subject to the supreme control of the Secretary of State, it is directed by a Chief Commissioner and his four assistants. According to the latest available returns, its strength is as follows:

Chief constables, 6; superintendents, 33; inspectors, 608; sergeants, 2687; constables, 17,011. Total, 20,345.

Every constable is informed upon enlistment that he may hope to rise by activity, intelligence, and good conduct to the superior grades; and as each position below that of chief constable is filled by the promotion of subordinates, the scope afforded by this democratic service to a zealous and able officer is very considerable.

Conditions of Entry. Every candidate for the Metropolitan Police must be over 20 and under 27 years of age, must stand 5 ft. 9 in. high (without boots or stockings), and must be free from any bodily complaint, and of a strong constitution. He must further be generally intelligent in the judgment of the officers before whom he presents himself, and must be able to read well, write legibly, and have a fair knowledge of spelling. He cannot be accepted, as a rule, if he has more than two children dependent on him for support.

The bodily complaints for which candidates are most frequently rejected include rupture, flat-foot, varicose veins, tumours, stiffness of the joints, narrow chest, and weak sight.

An application form for this service can be obtained from the Commissioner of Metropolitan

Police, New Scotland Yard, S.W., and should be filled in by the would-be constable, in the presence of the chief officer of police for his district, with certain particulars as to his age, character, and calling. The chief officer then measures and certifies the candidate's height and chest development, and the form, thus completed, is returned to the Commissioner's office. If this preliminary inquiry is satisfactory, the candidate receives notice to attend at New Scotland Yard one morning, where his measurements are checked and he is carefully examined by a police surgeon. Having passed this ordeal and given proof of his general fitness for police work, he is drilled for six weeks in squad exercises and the duties of a constable. His period of probation is now at an end. He is sworn in as a police constable, and posted to one of the 22 divisions of the force, where, after further instruction in his work, he finds himself at length a constable in earnest. During the first six months of his service he devotes alternate evenings to attending police instruction classes and night school.

Police Duty. Metropolitan police constables are required to perform eight hours' duty daily. Night work is always done in an unbroken spell, from 10 p.m. to 6 a.m.; day duty is performed either at a stretch or in two spells of four hours each. The work may be either patrolling a prescribed round (in official parlance, a "beat"), or standing sentinel at a fixed "point." The latter duty sometimes involves "traffic regulation"—the hated task of standing in the carriage-way at a crowded street corner, directing the never-ending cross-tides of traffic. As a rule, the officer is engaged during alternate months on night and day work. The latter is pleasant enough, save in the worst of weather; but the former, with its long, silent hours and its encounters with ruffianism and crime, is both tedious and trying. To secure a savage prisoner single-handed amid a hostile crowd, in "the wee, sma' hours ayont the twal," taxes all the novice's courage and skill. But tact and judgment, combined with a fearless bearing, are admirable solvents of the rough practical problems of street duty, whether they present themselves by day or night, and the young constable is not long in becoming seasoned to his work.

River and Mounted Police. In addition to the ordinary street officers, the Metropolitan Force includes two special branches—the Thames division and the mounted contingent. The river force is recruited entirely from sailors and boatmen, who must be able to swim and skilled in the management of small craft. For the mounted section, preference is given to men who have served in a cavalry regiment, but any officer who is an expert rider and understands horses can apply to enter it after six months' service on foot. Except that the horsemen are required to do 10 hours' duty daily—five in the saddle and five in the stables—both river and mounted officers are subject to the ordinary conditions of the service.

The Road to Promotion. After a few years of steady work in the ranks, a constable who is sober, reliable, and shrewd may look for promotion to the rank of sergeant. The first step toward this object is to obtain his superintendent's recommendation—generally through the kind offices of a friendly inspector. Candidates thus selected are first subjected to a preliminary trial in writing and arithmetic by the station clerk, and those who there acquit themselves passably, and have mastered police squad drill, are "sent up for sergeant."

The first and most trying part of the actual ordeal for promotion is an examination in police duty by a board consisting of a chief constable and four superintendents. The aspirant for the sergeant's stripes is required to make out written reports specifying exactly what steps he would take on a given contingency arising—a fatal fire, an accident to his Majesty's mails, the escape of a prisoner under arrest, or some such emergency. If his answers show both knowledge of police powers and discretion in wielding them, he is called before the examiners to answer *vivâ voce* a few searching questions based on the "police instruction book"—a formidable manual of police law and practice. Many candidates fail at this stage through nervousness or over-confidence, when an instant's quiet reflection would have saved them.

The survivors undergo a simple examination in writing and spelling, reading and copying manuscript, elementary composition, and the first four rules of arithmetic. Those who pass are then appointed sergeants as vacancies occur.

An intelligent officer is usually afforded two or three chances of "passing for sergeant," but only the specially recommended are promoted without examination.

The next grade—that of station-sergeant—is attained by passing a further test in knowledge of police matters before the examination board.

Inspectorships. For advancement to the grade of inspector a more difficult examination must be taken, the test of police duty being more exacting, and the arithmetic paper including weights and measures, reduction, and vulgar and decimal fractions. A capable, well-educated man, who does his duty with zeal and discretion, and has kept his "defaulter's sheet" clean, should be able to attain an inspectorship without undue delay. But the higher positions available, as sub-divisional and chief inspectors, and as superintendents, are so few and so eagerly contested that further advancement is naturally slow and uncertain. An examination in English and in advanced knowledge of police duties and administration is prescribed for each rank. Promotion is said to be slowest in the mounted branch.

The Criminal Investigation Department. The detective branch of the Metropolitan Force has its headquarters at New Scotland Yard, and, though officially described as the Criminal Investigation Department, it is better known to fame as the C.I.D., or "the Yard." It is specially devoted to the repression of grave crimes and such as involve elaborate inquiries or present other special difficulties; and if the work of this

department scarcely realises the sensational descriptions of novelists, it is in sober earnest very responsible and trying, and occasionally dangerous. On the other hand, the absorbing interest of detective duty, the special rates of pay for sergeants and higher officers of this branch, and the chances of personal distinction and valuable rewards, attract to the ranks of the C.I.D. the ablest members of the force.

To become a detective, however, is far from easy. Every officer is individually selected from the uniform staff, and must display in that capacity exceptional shrewdness and resource in dealing with crime ere "the Yard" will open its gates to him. The usual method of selection is to appoint a smart young uniform officer on probation for a while as a plain-clothes patrol. If he makes good use of this opportunity he is eventually transferred to the detective branch.

Pay, Allowances, and Pension. The various ranks of the Metropolitan Police are paid on the following scale, with increased allowances for special duty at the palaces and elsewhere. Whether calculated on the weekly or yearly pay, the increment is in every case an annual one.

Constables, 27s., by 1s. a week to 35s. a week, and after 15 years' service, 37s. 6d.

Sergeants, 40s., by 1s. to 44s. a week.

Sergeants (detective) in three classes, £2 2s. 6d., by 1s. and 2s. a week to £3 3s. 8d.

Station sergeants and clerk sergeants, £2 10s., by 1s. to £2 13s.

Inspectors (divisional), £3 2s., by 2s. to £3 10s.

Inspectors (sub-divisional), £3 17s. 6d. to £4 2s. 6d. a week.

Inspectors (chief), £4 12s. to £5 8s.

Inspectors (detective) in three classes, £3 6s. 6d., by 2s. and 4s. to £5 18s. 6d.

Chief Inspectors (detective), £6 7s. 6d., by 4s. to £7 7s. 6d. a week.

Superintendents, £340 a year, by £20 to £450 (six receiving £25 a year good service allowance, and one £50).

C.I.D. and other officers employed in plain clothes are entitled to an allowance in lieu of uniform; and, as uniform boots are no longer issued, inspectors receive instead 8½d. a week, and sergeants and constables 6d. Married officers of the last two grades, who are not accommodated in the police-station quarters, and whose rent exceeds 6s. a week, are entitled to an allowance "in aid of rent" which varies from 1s. 6d. to 2s. 6d. a week, according to the district in which they reside. Smart, well-conducted men are eligible for employment in the Houses of Parliament, museums, and Government offices, at an extra 1s. a day.

The scale of pensions for the Metropolitan Force is a very liberal one; indeed, it is the maximum permitted by statute. Apart from special rates for officers injured on duty, those who are invalided after 15 years' service, or more, receive proportionate life pensions. Further, the ordinary rates permit of retirement *at will*, after 25 years' service, upon $\frac{31}{50}$ths of full pay, or after 26 years at the maximum rate of two-thirds of such pay. Thus, a constable entering the force at the age of 21, and reaching the grade of chief inspector, for example, is entitled to retire at the age of 46 on a life pension of over £174, or at 47 on £187 a year.

City of London Police. This fine body, the admiration of all visitors to the heart of the capital, numbers some 1230 men in all. The conditions of recruitment are practically identical with those of the Metropolitan Police, save that the standard of stature, which never falls below 5 ft. 10 in., is at present fixed at 6 ft. The physique of candidates must be proportionate to their height. The hours of duty are the same as in the Metropolitan Force; but the City, thronged by day, and well lit and orderly by night, is a pleasanter patrol-ground than most districts in the Greater London area.

Salaries average higher for subordinate ranks than in the Metropolitan Force. Uniform constables, beginning at 28s. 6d., rise in six years to 41s. 6d. a week, and are eligible, after 15 years' service, for the "merit class," receiving 44s. All ranks draw 3s. a month for boots. There is, however, no rent-aid allowance. For sergeants, the maximum is £2 12s. a week. Higher posts are remunerated at about the same rate as outside the City; but chief inspectors of the uniform branch attain only £5 5s. a week. Detectives of all ranks receive ordinary pay, with an extra allowance ranging from 8s. a week for constables to 12s. for chief inspectors. The City pension scheme permits of retirement after 25 years' service on three-fifths of full pay; but to attain two-thirds it is necessary to serve for 29 years.

County and Borough Constabulary. The conditions of entrance into the numerous local forces comprised under these two divisions vary a good deal, particularly on the score of age. Some chief constables accept recruits as young as 19 years, and will not enlist them after the age of 25. In Scotland, under a general restriction, police recruits over 25 years of age are not accepted. A good many forces fix 30 as the maximum, but the average limits are 21 to 26 or 27, with occasional extension in favour of ex-Army men—who are generally in request for police duty. Candidates who contemplate joining a constabulary force should apply to the local Chief Constable, who will furnish them with the regulations of entry.

Many borough, and even county, forces are almost as small as Namgay Doola's army. Several of the former can muster a bare dozen officers for full parades; Louth, Congleton, and others are below even that modest figure, and have not a solitary inspector among them all. Of county forces, Rutland's is least, numbering 16 of all ranks; and Lancashire heads the county list with over 1900 officers. This latter figure, however, is surpassed by Liverpool, which boasts the largest borough force in this country, and one that merits special notice.

The strength of the Liverpool Police Force, according to recent statistics, is 2251 men (including 12 superintendents and 72 inspectors), and comprises a river force, a police fire brigade, and a small mounted contingent. Excluding the salaries of the Head Constable and his deputies, the rates of pay are as in the following statement.

Constables, 27s. to 35s. a week.
Sergeants, 38s. to 44s. a week.
Inspectors, £120 to £170 yearly.
Chief Inspectors, £180 to £220.
Superintendents, £250 to £420.
Chief Clerk (a police officer), £500 yearly.

The pension scheme provides for two-thirds of pay after thirty years' service, and there is a "merit class" for sergeants and constables, carrying extra pay.

The Transfer Clause. In county forces, and those of the smaller boroughs, the general level of salaries is somewhat smaller than at Liverpool. Constables' pay sometimes starts at as little as a guinea a week, and for higher grades the average rates are approximately as follow: Sergeants, 32s. to 37s. a week; inspectors, £100 to £130 a year; and superintendents, between £140 and £220. Further, many minor police forces, owing to the scarcity of higher positions, offer practically no prospects of promotion. Fortunately, however, there is a valuable provision in the Police Act of 1890, which enables an ambitious officer who finds himself so unfortunately placed to transfer, under certain conditions, to a more promising force, without forfeiting the service he has already rendered toward a pension. Under section 4, clause 4, of that Act, "an officer's approved service of not less than three years in any police force in the kingdom shall be reckoned as service in any other such force to which, with the written consent of his chief officer, he may remove."

The Chief Constable. The premier position of chief or head constable, in a county or borough force of any magnitude, is a valuable one, commanding an income of from £400 to £600 a year, and often considerably more. At Birmingham, Sheffield, and the West Riding the salary is £800, at Manchester £1250, and at Liverpool £1200 a year. These posts are rarely filled by direct promotion. Some are held by able officers from the Metropolitan Force, many others by retired officers of the Army and Navy, and several by ex-inspectors of the Royal Irish Constabulary.

With regard to pensions, the majority of police authorities have adopted the maximum scale which, as already explained, prevails in the Metropolitan Force. A number of them, however, instead of sanctioning voluntary retirement after 25 or 26 years' service irrespective of age, require officers to remain in the ranks until they are 50 or 55 years old, unless invalided earlier. In Scotland, 34 years' service is requisite to secure the full pension of two-thirds of pay.

Lists of the pay and pension scales of the many county and borough forces, with much other useful information, will be found in the unique little "Guide to the Police Services," which is published at 6d. by Mr. Kempster, 8, Red Lion-square, W.C.

Irish Police Forces. In lieu of a multiplicity of small forces, Ireland has two important ones—the Dublin Metropolitan Police in the capital, and the Royal Irish Constabulary throughout the country. The former, some 1300 strong, is based on the model of its London namesake, but with certain differences. Candidates must be between 20 and 26 years of age, of "a reasonable degree of education," and with some knowledge of grammar and arithmetic. They must be at least 5 ft. 10 in. in height, 36 in. round the chest, and 11 stone in weight. Each must also present testimonials from a magistrate or clergyman. The pay of constables rises from 23s. to 30s. a week, that of a sergeant from 34s. to 38s., of an inspector from £120 to £160 per annum, and a superintendent from £250 to £320. All the upper grades are filled by promotion from the ranks.

Royal Irish Constabulary. This notable body is practically a civil army of 10,500 officers and men. R.I.C. troops are housed in barracks, and trained to the use of arms; their drill and duties are semi-military at least, and their officers —as in the Army—are drawn from a class quite distinct from that of the rank and file.

Candidates for this service must be between 19 and 27 years of age, of good health and character, and unmarried. The minimum height is 5 ft. 9 in., and the chest development must be 36 in. at least. Sons of members or of pensioners of the force are admitted at 18 years if they are well built and stand 5 ft. 8 in. or more. Before admission, all candidates are examined in reading, writing, and the first four simple rules of arithmetic.

In addition to barrack-room accommodation and rations on the military scale, the pay of recruits is £39 a year. On completion of six months' service this becomes £54 12s., with allowances, and afterwards rises by increments of £2 12s. every three years (approximately) to £70 4s. After 25 years' service this is augmented to £72 16s., the maximum pay for constables. Sergeants receive from £78 to £83 4s., and head constables from £97 10s. to £104 a year. Prospects of promotion beyond this grade are very scanty. A pension of two-thirds pay may be claimed after 30 years' service.

Officers. Cadetships in the R.I.C. are awarded—usually to the number of eight or ten each year—on the result of competitions limited to candidates who have been nominated by the Lord-Lieutenant of Ireland. A minimum height of 5 ft. 8 in. is essential, as well as good sight and hearing, and a sound constitution. Details of the examination are given in the schedule on the next page.

There are also special competitions limited to the sons of constabulary officers.

A successful candidate, while undergoing his cadet's course of instruction, must be provided with a small allowance to supplement his pay; and, on being appointed third-class inspector, the cost of his outfit, which varies between £40 and £60, must also be defrayed.

The salaries of the Royal Irish Constabulary officers are as follows:

District inspectors (3rd class), £125; (2nd class), £165 to £180; (1st class), £225 to £300.
County inspectors, £350 to £450.
Town inspector, £600; and a few higher posts.

Advancement to the second class is generally speedy. In each grade a certain number of officers receive good-service pay.

The duties of the Royal Irish Constabulary have included in the past a great deal of distressing and distasteful work; but now that agrarian outrages on the one hand, and evictions on the other, are virtually unknown, the conditions of the service are greatly improved. It is plain that its monetary prospects—whether from the view point of the officers or their men —are not strikingly brilliant. Nevertheless, the outdoor life, and the soldierly character of the force, have always served to attract a considerable number of applicants for posts in each grade of the service.

Having completed our review of the police services, we may add a brief reference to the work of firemen, which is often performed by police officers as a special duty.

Fire Brigade Posts. The conditions of service probably vary more widely, according to the district, in this than in any other branch of local government work. Under the smaller councils, the fire brigade is either an amateur corps or at best a volunteer company receiving some such casual remuneration as a shilling for every hour of actual duty at fires. In larger areas it may comprise a small staff of salaried officers, reinforced by volunteers in time of need. Many borough councils regard it as a branch of police duty, appointing a special section of their force to act as firemen. This is the case with the Liverpool Constabulary, which includes a smart and well-equipped fire contingent, whose members receive an extra allowance. On the other hand, as in London, Manchester, and many other leading towns, the fire brigade is a large and distinct force.

The London Fire Brigade. This Brigade, the very type and model of an efficient service, is controlled by the County Council for the capital, and supported mainly by the rates, in part from the contributions of fire insurance companies, and to some small extent by a Government grant. It is, therefore, in essence a municipal body, and as the largest fire force in the kingdom, numbering 1480 of all ranks, it offers the widest scope to would-be recruits. For these reasons, its conditions of entrance and service merit our special notice.

Candidates for entrance into this small civil army, either as firemen or coachmen, should apply personally at the brigade headquarters, in Southwark Bridge Road, at 9 o'clock on any morning. Recruits are carefully chosen under the following conditions. They must be smart, strong, active men, of good character and education, between 19 and 31 years of age, at least 5 feet 5 inches in height, and 37 inches round the chest. Married men are rarely accepted for either branch. As far as possible, preference is given to London candidates. For firemen, service in the Navy or the mercantile marine is a very useful qualification.

Payment of Firemen. Applicants who satisfy these conditions, on passing a medical examination and a test of strength, are admitted as probationers, and undergo a course of instruction that lasts about three months, receiving 25s. 6d. a week meantime.

The pay of firemen on appointment is 26s. 6d. a week, and rises to 35s. Coachmen, who form but a small proportion of the staff, begin at 29s. 6d. and rise to 33s. a week. Uniform is in either grade provided free of charge. There are about 100 superior posts in the Brigade, as station officers, district officers, and superintendents, with salaries ranging from £130 to £255 a year, all of which are filled by promotion from the ranks. Lastly, that the fireman may face the risks of his calling without undue anxiety for those dependent on him, there is a liberal scheme in force of gratuities and pensions for officers, and allowances to their widows and children.

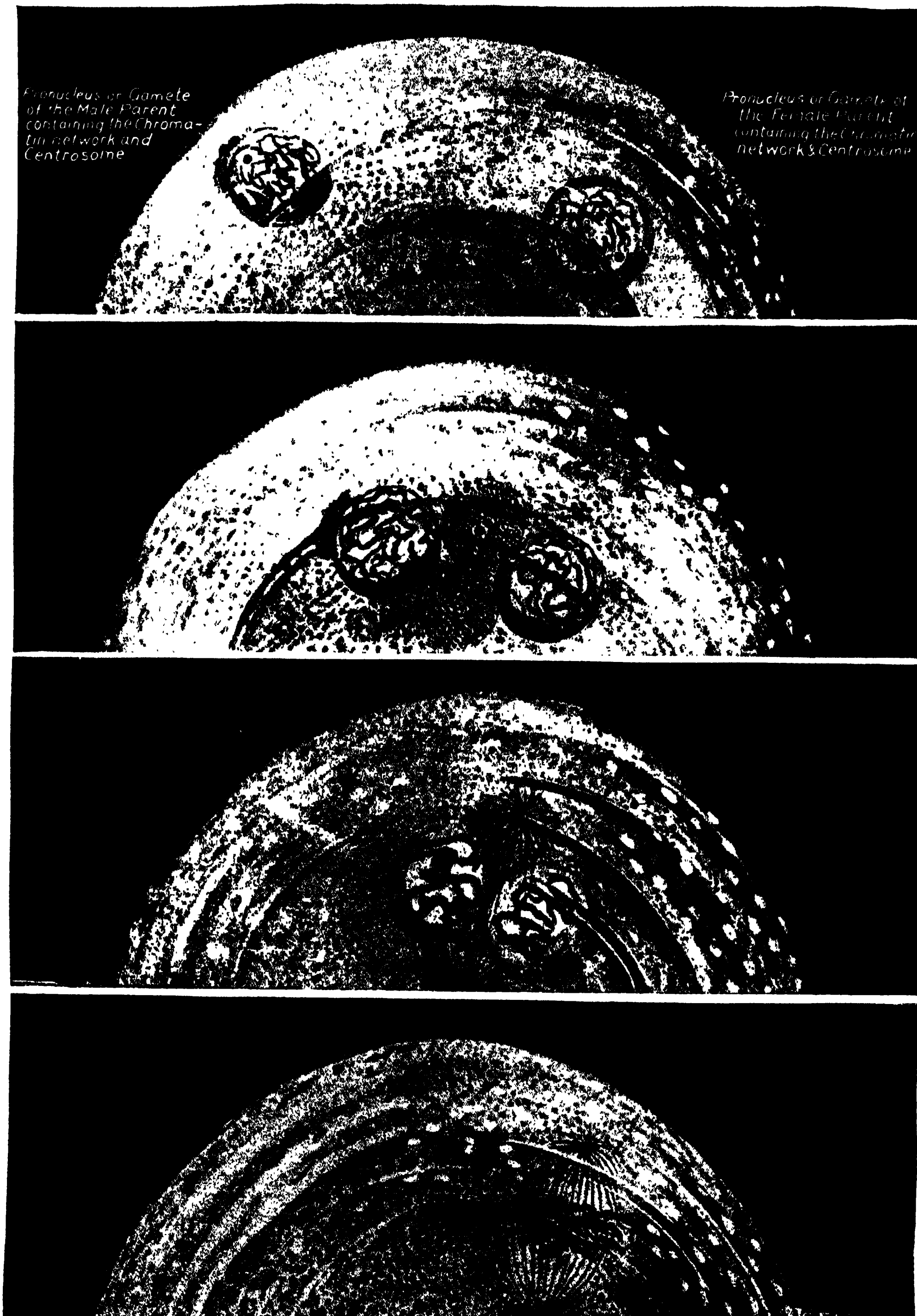
In provincial brigades, the initial pay of officers is about the same as in London, but the higher posts are not so well rewarded. Manchester pays its chief fire officer £500 a year, and his lieutenant £250, and the Birmingham chief officer's salary is £400; but, except in towns of such leading rank, the superintendent—who, as responsible officer, must have administrative capacity as well as practical experience—seldom receives more than £150 to £200 at the outside, with quarters, light, and fuel in addition.

ERNEST A. CARR

THE ROYAL IRISH CONSTABULARY CADET EXAMINATIONS

Examining Body, Time and Place of Examination.	Subjects of Examination	Fee and Age Limits.
Civil Service Commission. As required: Usually once each year. Dublin.	English Subjects: Arithmetic, Spelling, Handwriting, English Composition and Correspondence, Geography (especially British Isles), and British History (including Constitutional). Digest of Returns into Summaries. Précis. Latin or French. Principles of Law. Law of Evidence. Reading aloud (print and MS.). Note. There is an oral examination in French. All candidates must be nominated by Lord-Lieutenant of Ireland.	£2. 21 to 26 years. (19 to 26 for sons of Constabulary officers; 21 to 28 for officers of Army, Navy, or Police in certain instances.)

THE BIRTH OF HIGHER FORMS OF LIFE



This series of pictures is in a way complementary to those showing mitosis on page 1120. They represent the process by which is produced the first complete cell of plant or animal life. In the top picture the cells are seen approaching each other, and, as they come together, the centrosomes of the two cells leave the cells, and, as shown in the second picture, begin to develop the achromatin filament which ultimately links them, as in the third picture. The chromosomes attached to each filament now combine to form the first cell of a new organism, and the union of the two cells has thus created a power that neither had before—the power of building up a new individual.

The Fusing of Cells and its Meaning. Alternation of Generations. Why Cells Differ.

THE EVOLUTION OF SEX

p. 1120

In the last chapter we saw how cells divide, whether by fission, gemmation, or mitosis. In the first two cases, which occur only among very humble creatures, each having but one cell for all its body, we also saw that the new creatures, formed from the body of the parent, are already, at birth, practically adult. These creatures have no appreciable stages of growth or development, and the whole life-cycle of such a species is thus comprised in this one fact of splitting, splitting, splitting, or budding, budding, budding.

Cells that Coalesce. But even among these one-celled creatures we have lately found that something else occurs—not among all of them by any means, yet, to our surprise, among some. Of the microbes there is no more to say in this respect, nor has the strange fact about to be studied ever been recorded of the amœba. But it has been carefully studied in a minute, one-celled animal, only a little higher than the amœba, which is known as the paramœcium, and there are now known to be many other creatures, as simple or nearly so, of which the same is true. In the case of the malaria parasite, also a one-celled microscopic animal, the facts are even more complicated.

The discovery is that these cells not only divide, as we have seen them doing, but also conjugate or coalesce. We have watched one splitting into two, but now we find two fusing into one. What does this mean, what does it foreshadow, and what purpose does it serve ?

The Rejuvenation of Cells. The facts, as generally stated, are briefly as follow. We watch a paramœcium dividing, and its offspring doing likewise, until, after many generations, their powers seem to wane. They are less vigorous than their forebears, and they divide more slowly, until at last they even cease to divide at all. Then something novel and, as we might think, abnormal is observed. A couple of these tiny cells are observed to come alongside one another, and gradually to coalesce—just the opposite of the normal process by which the race of paramœcia is maintained. In time, the new individual, thus strangely formed from two, proceeds to divide in the ordinary way ; and the general belief among students is that the process of conjugation has *rejuvenated* the race. After conjugation the old vigour seems to return, and division merrily proceeds where formerly it had become slow, or had altogether ceased.

Let us look more closely still—though the microscope fails us too soon. If two paramœcia fuse into one, and that one then divides into two, the process might really mean one of two things. The same stuff which formed the original pair might again be distributed to the final pair. They would thus be themselves again, so to say, and we should see no reason why they should be advantaged by the process, as they seem to be. But there is good reason to suppose that this is not what happens. Instead there is a *redistribution* of the protoplasm of the two paramœcia, and when the creature formed by their coalescence itself divides, each of the products contains portions of protoplasm from each of the original pair. We believe that this exchange of part of the protoplasm of each paramœcium is the whole point and object of the process. There has been a vital fusion between two individuals, each of which, in the upshot, is found to have surrendered part of itself in exchange for part of the other. And they both are better for the process—if we can use such a form of words at all, for, in fact, they have ceased to be, while two new and more vigorous individuals are in their place.

The Renewal of Growth by Division. Such, briefly, is the fact of cell-conjugation as it is found among protozoa of many different kinds. We see that it is not really the reverse of cell-division. It does not go steadily backward, until, say, of 1024 paramœcia, we have at last only one—as it were the original ancestor to them all, now restored. On the contrary, conjugation is really a preliminary and aid to get further cell-division, and it seems to act as an efficient resource in rather desperate circumstances. We have almost everything yet to learn about it. We do not know to what extent it occurs under natural conditions, for we can watch these creatures only under artificial conditions. It depends upon states of nutrition, and can be affected in various ways by modifications in the composition of the nutrient fluids in which we watch these changes.

How Nourishment Prevents Failure. Some recent observers seem conclusively to have shown that the older views were incorrect in one important respect. The first students said that the time invariably came when the colony showed signs of failing ; division slowed down, movements became feebler, and, indeed, the death and extinction of the race was at hand. Then, perhaps, conjugation would keep it going. But lately, thanks to advances in the chemical side of the question, students have been able to keep such colonies alive almost indefinitely, the reason clearly being that the observer has been able to supply nourishment, which is easy, and to remove poisons, which is difficult, so thoroughly that the life of the colony showed no signs of failing. This is very important, for it suggests that there is not, as was supposed, any *inherent* reason for the failure of these colonies. They began to die

not because it was the law of their lives that this should be so, but because they were being poisoned under the conditions of the experiment.

The Benefit of Cross-breeding. Another notable observation is to the effect that, if some paramœcia of another strain, from another colony, be introduced, the result is highly favourable. This suggests a parallel with the results of cross-breeding among much higher forms of life as compared with continuous in-breeding, or mating among close relatives. Already the student will begin to find his suspicions strengthened that in cell-conjugation there is foreshadowed something much more familiar, of which no word has yet been said in our study of life. In fact, suspecting something more than merely a curious resemblance between conjugation and the phenomena of sex, Professor Raymond Pearl, a distinguished American student, recently made interesting measurements.

He came to the conclusion that, while individual paramœcia vary in length, just as we do in stature, those which conjugate tend to be of the same length as each other—longer mate with longer, and shorter with shorter. But this is exactly parallel to what Professor Karl Pearson concluded, several years ago, when studying the laws of human mating. He found that tall people tend to intermarry, blue-eyed people to intermarry, and so on. This fact, of the tendency to marriage among the similar, he called *homogamy*, and now it looks as if we might apply a similar term to the facts of cell-conjugation among the paramœcia. But is not that almost as much as to say that the paramœcia display the fact called sex? And do they?

Asexual Reproduction in Protozoa. Hitherto, we have not needed to note that there were, for instance, two kinds of coccus, bacillus, or amœba, respectively male and female. Nor are there two kinds of paramœcium. Sex, as we understand it, does not exist among these simplest visible plants and animals; it has yet not been evolved. When they reproduce, the individual divides, without the aid of any other. These are *asexual* forms of life, and the modes of reproduction which they exhibit, and which we studied in the last chapter, are rightly described as *asexual reproduction*. When two paramœcia, in their strange way, conjugate, prior to further reproduction, we cannot detect any difference between the two members of the conjugating pair. No one could call one of them male and the other female. Among higher types of life the two sexes exist, and individuals of either can be readily distinguished. The species exists, in fact, in two sexual forms, and this feature of the species, which applies to nearly all the forms of life, is known as *sexual dimorphism* (Greek, *morphe*, form).

Resemblances in Higher Life Forms. But as the paramœcium does not show sexual dimorphism, and as its normal mode of reproduction is asexual, we cannot assert sex of this creature. Yet, when we study the facts of sexual reproduction, higher up in the scale of animals or plants, we shall find that what happens is fundamentally the *same* as in cell-conjugation among the protozoa. Two cells—which in these cases are different in form, and come from bodies different in form—conjugate and become one. Then this one divides, and into its products go parti[illegible] sexual cells. This is more than a mere chance resemblance, surely, to what we observed among the paramœcia.

Stages in the Evolution of Sex. The truth doubtless is that, among these humble one-celled protozoa, we are observing the earliest stages in the *evolution of sex*. True, there is as yet no sexual dimorphism, but then we must remember that these creatures are individual and sex-cell in one. In a sense, they have no *bodies*, and it is the bodies of the higher animals and plants that differ so markedly in the two sexes. The sex-cells usually differ, too, but sometimes they do not. Further research may show that conjugating paramœcia really differ chemically. True, also, this conjugation is not essential to the reproduction of the species. It is relatively unusual; it may be abnormal, and unknown in the natural history of the race, but the fact remains that paramœcia, in certain circumstances, are capable of it; and when they do behave in this way, it is as near true sexual reproduction "as makes no difference." We must also learn that this curious power of alternative is not unknown among vastly higher forms of life, in many of which, though they show sexual dimorphism, and though their normal mode of reproduction is sexual, the females can nevertheless give birth to offspring without sexual conjugation, this fact being known as parthenogenesis. It is illustrated among the bees, and many other insects.

Therefore, all these circumstances being considered, we must conclude that cell-conjugation among the protozoa shows us the initial or premonitory stages of the evolution of sex—that tremendous and central fact of all the higher forms of life. And, within the last decade or a little more, a new kind of evidence has been available. It might seem far-fetched to call conjugation among the protozoa a sort of anticipation of sexual reproduction, when there was no evidence of the existence of true sex until a vastly higher stage in the evolutionary scale. But now we have evidence of actual sex, quite obvious, among the protozoa themselves.

Sex Alternation in Generations. The writer well remembers his incredulity when the assertion was first made that there was a sexual stage in the life-history of the malaria parasite. This is a microscopic unicellular animal, not unlike the amœba, and the notion that such a creature could display sex seemed absurd. But it does so. It has a complicated life-cycle, with two distinct parts. In one phase it is an asexual creature, like the amœba. But from this asexual form *two* forms may arise, which are respectively male and female, and which conjugate as such. This sequence was already well known among many animals higher up the scale, and is almost universal among plants. The technical name for it is *alternation of generations*. As a rule this

alternation of sexual and asexual generations proceeds with regularity, but among such protozoa as the malaria parasite there is much more freedom. Apparently it can do as it pleases, according to the circumstances, and [illegible] generations may succeed one another for long periods, as in the case of the paramœcium. Students of malaria find that quinine affects these processes, and that the various stages of the disease, the "cold fit" and the "hot fit," and so on, correspond to and depend upon certain stages in the generative life-history of the parasite. They have also learnt that it is just when a certain stage in the life-cycle is in process that a dose of quinine in the blood will do most harm to the parasite and good to its host.

Sex in the Humblest Forms of Life. But for us the point is that, among one-celled animals called protozoa, we find, first, uninterrupted asexual reproduction, as in amœba; second, asexual reproduction, with the alternative, under some conditions, of a cell-conjugation which can scarcely be calle[illegible] less than, shal[illegible] we say, pre-sexual, as in the paramœcium, though sexual dimorphism has not yet appeared; and third, also [illegible] alternation of generations, with sexual dimorphism in the sexual generation, where the two kinds of cells can be readily distinguished, as in the malaria parasite. Thus, even among the one-celled animals, the humblest that can be seen, and doubtless the humblest at all that can fairly be called animals, we have encountered already the existence of sex, which we know to be so dominant and deep a fact in the lives of the highest of living beings.

Complete Diffusion in Cell Division. Let us look now at the minuter details of cell-conjugation, for we can hardly expect it to be a haphazard affair. When we studied cell-division among forms of cell high enough to possess a nucleus, we found that the nucleus is really the all-important structure in the process. We saw that its most characteristic portion, the chromatin, went through a most elaborate series of changes, the object of which seemed to be the exact apportionment between its two daughter-nuclei of every iota of its substance. We realised, further, that this must be the key to the fact of heredity, which could not be what it is if the nuclear division were any less detailed and scrupulous. We saw, also, how the splitting of the chromosomes ensures the maintenance, in each daughter-nucleus, of the number of chromosomes which is characteristic of the species.

The Process of Nuclear Fusion. All this will prepare us easily for the facts which are observed when nuclei unite. In the process of cell-union, again, it is the nuclei that are all-important. (Among cells that have no nuclei, such as the bacteria, cell-union is unknown, [illegible] of course, cell-division occurs.) [illegible] process may fairly be described as, in principle and detail, exactly the reverse of karyokinesis or mitosis. Each of the conjugating nuclei begins by unwinding its chromatin network until it becomes a thread, which breaks up into the number of chromosomes characteristic of the species. So far as this is concerned, each nucleus might be about to divide, as its habit is. But its intent is now different, and there is no sign of the splitting of the chromosomes, and the subsequent processes seen in mitosis. By this time the cytoplasm of the two cells has fused, so that the nuclei are in apposition; the boundary between them breaks down, and the chromosomes of the one become apposed to the chromosomes of the other. Belonging, as they do, to the same species, the number of chromosomes is the same in both nuclei. So is the number of pairs, of course, and when the chromosomes have fused, the new nucleus is seen to contain, as ever, the number of chromosomes characteristic of the species we are studying. Then the chromosomes settle down again into a thread, which become coiled upon itself, and the process of nuclear fusion is complete.

What the Malaria Parasite Teaches. If it be one of the humblest forms that we are studying, then cell-division of the customary type is all that will follow. Or the type may vary. For instance, in the case of the malaria parasite, we sometimes find the parent cell breaking up into not one but quite a brood of youngsters. Nevertheless, in all the protozoa, nothing but one-celled forms of an individual ever appear. Immeasurably different is the case of all the higher animals and plants.

In them, also, at one momentous epoch in the life-cycle, a single cell—formed by the body of a male individual—unites with a single cell formed by the body of a female individual. Nuclear fusion occurs. In fact, this is a process closely similar to cell-conjugation as we have already studied it. The result, as in that case, is a single cell. But how different its subsequent behaviour! This single cell, with its single nucleus, proceeds to divide, just as if it were an amœba, or a paramœcium after conjugation. The one nucleus becomes two, and the cytoplasm follows suit. There are two cells instead of one. But these two cells *remain united*, instead of separating, and become two complete individuals, as they would if they were amœbæ or paramœcia. Yet each of these cells, in its turn, divides, as if it were an independent one-celled organism—*which it is, and yet is not.*

The Development of a Multicellular Being. So the process continues, each new cell dividing into two, as if it were dealing with the successive generations of a colony of paramœcia, all derived from one cell.

The difference is that, in that case, the new cells become detached and independent; but in this case—and we may be talking about a starfish or a mushroom, or a whale or an oak or a man—the successive asexual generations of cells—for that is what they are—remain united to one another. We are witnessing the development of the body of a multicellular animal or plant, by an unthinkably numerous series of asexual cell-divisions which began in the single cell we saw formed by cell-union. It is a notable fact that so exact and minutely

scrupulous are these successive divisions as to ensure the presence of substance derived from both the paternal and the maternal sexual cells in every cell of the resulting individual body.

Single Cells that Form in Clusters. But now observe the most important fact of all which we have not yet mentioned. So far, as we have explicitly stated, the *segmentation nucleus*—as it is called to indicate its destiny—might yield only cells all similar to itself and each other. They would be united, we said, and would thus form a "body," probably spherical, all composed of similar cells. The only difference between such an object and a colony of paramœcia would be that in this case the various individuals were in physical contact, while the paramœcia are not; and such a difference would be hardly worth mentioning. Indeed, even among the bacteria, the individuals often remain more or less united, and form long chains, as in the case of anthrax bacillus, or go about in pairs, like the *diplococcus* (double coccus) of pneumonia, or in grape-like clusters, like the therefore so-called *staphylococcus*, or common inflammation. In such clusters or chains or similar physical associations all the individuals are complete, similar, and practically independent, and the organism in question is still rightly called unicellular.

Many-celled and one-celled Forms of Life. But consider what will be likely to happen if a single cell divides into, say, 64 or 128 which form a globe. The cells on the outside of this globe are now in a conspicuously different relation to the rest of Nature from that of the cells within. Indeed, the internal cells can get neither food nor oxygen, nor water, except through the outer cells, and without these they will die. The outer cells, on the other hand, have food and oxygen and water bathing their external surfaces, while they have hungry cells, like themselves, in contact with their internal surfaces. It stands to reason that, in such a case, thanks to the difference in circumstances, if to nothing else, the various cells in such a sphere must *become different*, and so they do. This is the stupendous fact upon which all else depends. For the difference between the many-celled and the one-celled forms of life is not merely numerical. If that were all, it were negligible. The point is that the many-celled creatures are also *different-celled* creatures; and upon that fact their lives and powers depend.

The Importance of Cell-Surface to Cells. It was Herbert Spencer who first discovered the underlying laws of these wonderful processes. First, he taught us why cells divide at all. Reproduction, he said, may be looked upon as "discontinuous growth." The yeast cell, for instance, grows and grows. But when it reaches a certain size a difficulty arises. By this time its surface, which is, so to say, its mouth and lungs, has become smaller relatively to the mass and its contents. The bigger it grows the more inadequate becomes the extent of its surface in proportion to its contents—according to a simple mathematical law. The cell may therefore stop growing, as some cells do. But if it is to go on growing it must divide. Then the same amount of stuff as was in it just before division is now provided, in the form of two cells, with a proportionately larger *surface* than the parent cell had, and its nutrition becomes easier. This simple discovery of Spencer's clearly underlies cell-division, and it explains the fact that, throughout the whole living world, cells of all kinds never exceed a certain very small size.

The Rise of Cell-Differentiation. Next, we have seen that, when the subdividing cells remain united, they begin to assume different relations to the environment. It is a law of necessity, therefore, argued Spencer, that they must become different; different causes acting on the same material must produce different results. Hence the fact that cell division and multiplication, in forming the body of any many-celled animal or plant, involves *cell-differentiation*. Of course, we must beware of attributing too much to this explanation. It shows why the cells upon the outside of the developing globe of living cells must become different from those at its core; but in the development of living beings as we now know them, nothing is more certain than that the differences between the various sorts of cells are *predestined*.

Some, indeed, are so composed, and have the necessary ferments and powers so distributed to them, that they must become brain cells, others liver cells, others skin cells, and so forth. Only Spencer's observations may help us to guess, too vaguely, how these differences may have *arisen* when the many-celled creatures began to be evolved. His recent experiment has shown us the inevitable predestined necessity by which, when the segmentation nucleus divides, the daughter-cells will become some of one kind and some of another; for when we artificially disturb the cell relations of an embryonic form of life we find that, to a large extent, the cells which would have assumed a certain type in their normal position do so, or try to do so, even when they have been displaced. They do also try to adapt themselves to the unforeseen circumstances, but their very difficulty in doing so shows how different they were meant to be.

The Mystery of Diversity. The fact is clear that the bodies of the many-celled animals and plants are formed by the successive cell-divisions of one cell and its offspring, and that in their course the cells assume different types for different functions. We find, in the cell society we call a higher plant or animal, the *division of labour* which is found in all human societies too. And if we begin to think that we are now getting "to know all about it," we may ask ourselves how the special powers and forms of all the myriad types of cells in our bodies are predetermined and contained in the single cell, less than one-hundreth of an inch across, which was the common ancestor af them all. Indeed, so far are we from "knowing all about it" that we have merely peeped into the arcana where Nature still conceals all the mysteries of sex, and heredity, and development.

C. W. SALEEBY

How to Write and Answer a Business Letter.
The Correspondence Department. Filing. Telegrams.

BUSINESS CORRESPONDENCE

When we remember that for the year ending March 31, 1912, there were delivered in England no fewer than 3,186,800,000 letters, 905,500,000 postcards, and 124,254,092 postal parcels, and that by far the greater proportion of these were commercial communications, we can quite understand that correspondence plays a very important part in the regular routine of business.

Importance of Correspondence. By means of letters an ever-increasing amount of commerce is carried on between persons who have never seen one another; and the trader in London can, through the post, get into close touch with people in the five continents and at the uttermost parts of the earth. Personal interviews are good, but there are times when a letter is a better and safer means of communication than a conversation, for the words of a letter can be considered and reconsidered, whereas the word of mouth, once spoken, is spoken for ever. Not only so, but letters are absolutely necessary as confirmations of verbal agreements, and a contract concerning goods to the value of ten pounds or upwards must be made in writing, or it cannot be legally enforced.

An Accomplishment Worth Cultivating. Shakespeare's statement that "any man that can write may answer a letter" was possibly true in his time, but it is far from the fact today—in the business world, at any rate. To be able to write a thoroughly efficient business letter is an accomplishment that any commercial man may well covet. It is so easy to write what we never intended to write, and in the world of commerce such mistakes are serious.

Full oft have letters caused the writers
To curse the day they were inditers.

Every man should, of course, aim to put his individuality into business letters as he should into his private correspondence; but, at the same time, there are certain well-defined usages and customs which must be followed out, and in these pages it is intended to set forth general principles that should be known by every man working in the correspondence department of an up-to-date business, and to give a general description of the methods of handling and filing the correspondence received and sent out.

The business value of a really well-composed letter is tremendous, and more and more attention is being paid to the correspondence department in all modern businesses, large and small. In many big concerns, at least 50 per cent. of the turnover is business obtained by letter, and not by direct personal solicitation, and it is safe to say that the man who can write a really good letter will sooner or later have an opportunity of rising to a position of responsibility.

The Characteristics of a Good Business Letter. Every business letter should have a number of well-defined characteristics. In the first place, it should be perfectly grammatical in construction, clear in meaning, accurate in its facts, and persuasive in its appeal, whether the appeal be for order or remittance, whether it be an apology for delay, or whether it deal with any other matter. Then the form of the letter and its general appearance should be attractive. Misprints or wrong alignment in typing, slips in punctuation, blots and smudges and finger-prints, all militate against good business, and predispose the recipient of a letter agains tthe firm from whom it emanates.

Let us consider in some detail the form and appearance of the letter. All business correspondence should now be typewritten. The general working and management of the various kinds of typewriters is described in another part of this book, and it is only necessary to say here that all the letters sent out by one firm should be uniform in style as to spacing, margin, and so on. The general custom followed by the largest firms is to have single spacing between the lines and double spacing between paragraphs. Margins of at least an inch should be left on either side, and the name and address of the firm or person to whom the letter is going must be typed at the head.

Margins. All the lines of the letter, including the name, address, "Dear Sir,", etc., with the sole exception of new paragraph lines, should start at exactly the same distance from the left-hand edge of the paper, so that when the letter is complete the margin is the same width all the way down. The typing of the letter should not begin immediately under the printed note-heading, and if the letter is to be continued on a second sheet care should be taken that a few lines of the text, at least, are carried over. The appearance of a typed letter depends a good deal upon the colour of the ribbon used, and the purple ribbon, because it lasts longest, is favoured by most firms. Those businesses, however, which wish to give an air of distinction to their letters and raise them above the ordinary level use blue or black or green ribbons, and certainly such colours give a characteristic note to the letter. Such points are not to be ignored by any firm that desires to adopt every possible means of distinguishing itself by efficiency and originality in an age of severe competition.

As to general form, the business letter is very much like any other letter. There will be a salutation, "Dear Sir," to a single individual.

and "Dear Sirs" or "Gentlemen" to partners or a limited company. There are various ways of beginning a letter, and here are some examples:

We are in receipt of your letter of the 14th inst., and in reply beg to say, etc.

We have your letter of the 10th inst., and regret that we cannot, etc.

Your letter of the 31st ulto. came to hand this morning, and we hasten to inform you that, etc.

We received your letter of the 17th inst. today, and beg to thank you for, etc.

We beg to acknowledge the receipt of your letter of the 1st inst.

In reply to your letter of the 21st inst., we may say, etc.

Similarly, there are various forms of ending, some of which are given here:

Trusting that you will give the matter your careful attention, We are, Yours faithfully.

Thanking you in anticipation for the favour of a reply, We are, etc.

Trusting that we may have the pleasure of receiving your order in the near future, etc.

Hoping to hear from you in due course, etc.

Awaiting the favour of your further reply, etc.

Regretting that we are unable to fall in with your wish, etc.

Trusting that this scheme will work to our mutual advantage, etc.

Beginnings and Endings. These are, of course, only a few specimens. The particular form used will depend largely upon the subject matter of the letter. We must be quite sure that the ending of the letter is grammatically complete, that the sentences used contain their proper verbs. For instance, we often come across a business letter ending in this way: "Trusting that we may hear from you in the course of the next few days. Yours faithfully." Of course, after "few days" should come the words "We are," and then "Yours faithfully." At the beginning of business letters, too, it is very common to find a phrase such as "With reference to yours of the 10th inst," and then a full-stop. There should be a comma, and the letter should continue, "we find that," or "we regret that," and so on.

How to Address Different Correspondents. A word may be said here about the form of address—that is, the method of addressing various kinds of correspondents. To a limited company with a general name we write, "The Secretary," or "The Manager," or "The Cashier," The British Aeroplane Company, Ltd., and start the letter "Dear Sir." Or we may address the letter to "The British Aeroplane Company, Ltd." and begin "Gentlemen," or "Dear Sirs." To a firm or a company bearing the surnames of partners we write, "Messrs. Jones & Brown," or "Messrs. Robinson & Co., Ltd.," and begin "Gentlemen," or "Dear Sirs." To a firm composed of ladies we write, "Mesdames Smith & Brown," and begin, "Ladies." A business house consisting of a single individual is addressed as Mr. William Evans, or William Evans, Esq., and the letter begins, "Dear Sir." French firms are addressed as M. or Monsieur So-and-so for single names, and MM., or Messieurs, for firms of more than one name. To German firms we write Herrn for an individual, and Herren for more than one. To Italian firms, Signor and Signori; and to Spanish firms, Sr. or Señor, and Sres. or Señores.

Clearness, Conciseness, Correctness. In the body of the letter several things must be aimed at. They are, first and foremost, clearness; secondly, conciseness, despite Dr. Johnson's statement that "a short letter is an insult"; and, thirdly, correctness. The number of business men who can write a really clear letter is astonishingly small. An aspirant for place and power should practise the art of expressing himself with absolute clearness. In this connection several things should be borne in mind. To write clearly we must think clearly, and therefore, before attempting to dictate or write a letter, the correspondent should himself know just what it is he wants to convey to the man to whom he is writing. It is a good idea when writing a letter to think how we would put the matter if we were speaking to the correspondent. We can most of us make our meaning clear when speaking, and with a little practice it should not be difficult to do so in writing.

We must, of course, in the letter, set forth the various facts with which we wish to deal in their proper sequence. A common failing in business correspondence is that, after dealing with a certain matter and then going on to another, the first matter is again referred to. Such a method of writing always militates against clearness, and is to be carefully avoided.

Importance of Brevity. But something more than clearness is needed. We must be brief, or our letters, however good, will never be read. Business men have not the time to wade through long letters, and so we must aim at conciseness. This is quite as difficult and quite as valuable an accomplishment as being able to express oneself clearly. Without giving a choppy and disjointed appearance to a letter, the sentences should certainly be short and crisp.

Then the spelling, grammar, and diction of the letter should be correct. Large numbers of highly educated men are now going into business, and the ungrammatical and illiterate letter is not likely to prepossess these men in favour of the writer or his business. Grammar and composition are, of course, dealt with in another part of this book, but a few useful hints may be given here.

Grammatical Pitfalls to be Avoided. Write accede *to*, not accede with; accompanied *by*, not with; acquiesce *in*, not with; adapted *to* a condition; adapted *for* a purpose; agree *to* a thing; agree *with* a person; annoyed *at* a thing; annoyed *with* a person; averse *from*, not to; call *upon* a person; call *at* a place; compare one thing *to* another by way of illustration; compare a person or thing *with* another in regard to quality; different *from*, not to; divide *between* two; divide *among* more than two; an exception *from* a rule; take exception *to* a statement; exchange *with* a person; exchange one thing *for* another; part *with* a thing; part *from* a person.

Never split an infinitive thus: to nearly achieve, write "nearly to achieve." Never write *and* before *which*, unless *which* has been previously used in the sentence, thus: "This is the case *which* we received from abroad *and which* we sent on to you." Be careful in the use of pronouns, particularly he, she, it, and they. Here is a sentence the meaning of which is anything but clear: "The manufacturer wrote to the agent saying that if he did not receive the goods soon he would find himself in an awkward fix." To whom does the *he* refer? Be careful also that adverbs are put in their right positions in sentences. "We only want one gross of these cases" is incorrect. Write, "We want only one gross," and so on. Say, "We are always glad to see samples," not "We are glad to see samples always."

Avoid Tautology. Never use unnecessary words which duplicate the meaning. In the following sentences the words in italics are unnecessary:

Divide *up* into its component parts.
Settle *upon* what is to be done.
We have decided to restore it *again*.
We have the *entire* monopoly for *all* Europe.
We decline *to accept* your offer.
We hope you will *continue to* remain.

Avoid also hackneyed phrases, such as: "Yours of even date"; and vulgar abbreviations like "gents" for "gentlemen," "Yours, etc." for "Yours faithfully," and so on.

Punctuation. This should be carefully attended to, for it is of more importance in business letters than it is in ordinary correspondence. A stop may often alter the whole sense of a declaration, and lead to serious disputes about large sums of money, and in one instance the misplacement of a comma caused a loss of two million dollars to the Government of the United States. In a Tariff Bill about a quarter of a century ago there was a sentence setting forth the articles that were to be admitted free of duty. Among the articles thus specified were "all foreign fruit-plants," meaning, of course, plants for propagation or experimental purposes. The clerk, in copying the Bill, accidentally changed the hyphen in the compound word fruit-plants to a comma, making the phrase read, "all foreign fruit, plants," etc. The result was that for twelve months, until Congress could set the mistake right, all oranges, lemons, bananas, grapes, and other foreign fruits were admitted free of charge.

It is therefore essential that the business man should be particular about his punctuation. On the other hand, no letter should be so carelessly and ambiguously constructed as to depend entirely upon punctuation to make its meaning clear. The proper use of the various stops—full-point, comma, semicolon, colon, dash, exclamation mark, apostrophe, interrogation mark, quotation marks, and parenthesis—is fully explained in the course in ENGLISH, and needs no repetition here. Emphasis is usually given by means of underlining the words, but in many up-to-date offices it is conveyed by typing the emphatic words in ink of a different colour from the rest of the letter. This method is very effective.

Accuracy. Seeing how important is accuracy, all prices, dates, terms, and so on should be carefuly checked after being typed. The language of a letter should, of course, be polite, the tendency in the commercial world being toward a greater courtesy. At the same time, the old-fashioned fulsome expressions such as "Your esteemed order," "Your valued remark," "Your good selves," "Your obedient servant" have almost dropped out of use. A business letter should never be written in haste or temper. If anything has happened to rouse our ire, it is essential that the writing or dictating of a letter dealing with the matter should be left till cooler moments. Private affairs, too, should never be introduced into a business letter. If the correspondents are personal friends, and wish to say something private to one another through the post, they should write separate letters, and not put a personal paragraph or postscript into a purely business letter.

How to Write Dates. A date in the current month is referred to as *instant*, and is written thus: the 21st instant, or the 21st inst. The coming month is referred to as *proximo*, or *prox.*, and the past month as *ultimo*, or *ulto*. Any month farther back or forward should be referred to by name. There are various technical terms and phrases common to all businesses, besides those peculiar to particular trades, and the correspondent should see to it that he is familiar with the proper use and meaning of all these. It is important, however, to be quite sure that the recipient of a letter will understand the technical terms used, otherwise they should be clearly explained in popular and familiar language.

Correspondence should never be left over without attention. A reply should be sent at once, if it is merely an acknowledgment preparatory to a fuller reply. As far as possible all correspondence should be dealt with early in the morning, so that the clerk has plenty of time to type letters for the manager or head of a department to read through before signing. Late work is not good for the clerks, and habitual late-postage fees mount up to a very large sum by the end of the year.

Be Careful to Answer all the Points of a Letter. In answering a business letter we should be careful to see that all the points raised by our correspondent have been dealt with, and that our letter really is an answer to his. It is astonishing how many business letters beat about the bush, and do not give the information that was asked. Postscripts should be avoided as far as possible in business letters.

Every letter sent out should be self-contained, that is, it should be so worded that, without any reference to the letter to which it is a reply, the matter under discussion can be seen at once. Here are two examples, the first of which is the wrong kind of letter to write, and the second is a correct form. "Dear sir, we have your

letter of the 30th ulto., and regret to say that it is impossible for us to do as you wish in the matter about which you write.—Yours faithfully," etc. "Dear Sir,—We thank you for your letter of the 3rd inst., and regret that we cannot send you one of our No. A1 bicycles upon approval, as we have been compelled by past experience to make it a rule never to do business in this way.—Yours faithfully," and the signature. A great deal of labour in referring back is saved by being thus explicit in all letters.

The successful business correspondent is the man who can put himself in the place of the other man, and settle that man's doubts, meet his objections, and convey to him the information he is seeking in the way he can best understand it. If we are trying to make the other man buy our goods, we must, after writing a letter, ask ourselves: "Now, were I the person receiving this letter, should I be convinced by the arguments and send an order?" Unless we can answer in the affirmative our letter is lacking, and should be overhauled. To see things from the other man's view-point, and then to make him see things from ours, is the keynote of success. It is the ideal we must strive after.

Importance of Languages to a Correspondence Clerk. Of course, letters to a foreign firm should be written in the language of the country to which they are going, and therein lies the importance of a correspondence clerk making himself proficient in other languages than his own. Then, in writing to people of our own language across the Atlantic and quoting for our manufactures, it is important to give the figures not in English money, but in dollars and cents. This point was very strongly emphasised at a recent conference of business men held at the London Chamber of Commerce to discuss trade between England and Canada.

Brief notes which are mere formal acknowledgments of letters or goods received are sometimes sent out on memorandum forms. These notes do not begin with the salutation "Dear Sir," and are not signed; but such methods of conducting correspondence belong really to an old order of things, and it is more and more getting the custom to give all letters, however formal and brief, a proper beginning and ending.

Correspondence Inward and Outward. So far we have been dealing entirely with correspondence sent out *from* the office, and known technically as *outward correspondence.* As a matter of fact, before there can be any letters sent out, the inward correspondence must be received, and it is necessary to explain how this is handled in up-to-date business houses. Letters are usually opened by someone in a position of authority and responsibility, such as the chief accountant, the secretary or assistant secretary, or the private clerk of the managing director. A junior clerk sits by him and slits the envelopes open. If the post is very heavy, then probably two responsible persons undertake the opening and sorting of it.

As the letters are opened they are placed in various piles or baskets, according to the departments for which they are intended. Thus, all cheques and postal orders are put in one pile for the cashier's department; all letters referring to publicity, showcards, distributing schemes, and so on are put in a pile for the advertising department; quotations in another pile for the buying department, and so on.

The letters are usually stamped with a rubber date-stamp, so that there may be no question as to when they were received; and where the various posts through the day are heavy, the date-stamp may record also the time of receipt. Some firms have their date-stamp rather more elaborate, a line with the words "Attended to by ————" being added, so that when the letter is answered or the order executed the person dealing with it can sign his name or initials. Responsibility is thus properly fixed.

In many offices a correspondence book is kept, and in it the names of the writers of all letters received each day are recorded, with possibly a brief summary of the contents of each. It is usual also to write across the corner of all letters in which money is enclosed the amount received and the form in which it came to hand, thus: "Cheque £13 2s. 5d.," "P.O. 5s. 6d.," "P.O.O. 21s." Sometimes the book in which inward correspondence is recorded is made the post book, and the date of the reply and the postage are added to each name.

Each Business Must Organise its Own Details. No hard and fast rule can be laid down, for businesses differ so much that there can be no uniform best way for all. Each particular house must organise its own system, based, of course, on general principles which hold good for all trades. The great essential is that there shall be a complete record of all correspondence received and sent out, so that in case of queries arising the whole story of a transaction can be followed and the responsibility fixed upon individuals for each step of a transaction.

When the whole of the post has been sorted, the letters are placed in table-baskets or manila folders and sent to the various departments which have to deal with them. The order department, of course, books all orders and copies them out on proper forms, which are sent to the despatch department. Each department answers its own letters, and with regard to the signature the custom varies.

Methods of Signing. In some businesses all letters are stamped with the name of the firm, and the actual writer of the letter simply signs his initials. Such firms usually have printed at the head of their note-paper some such words as: "All letters to be addressed to the firm and not to individuals," and the signature is placed after "Yours faithfully" by means of a facsimile rubber stamp used with a black ink pad. It will be found a convenience where such stamps are used to stick a drawing-pin into the handle on one side, or in some other way to indicate which is the top of the stamp, otherwise there is danger that the letters may be stamped with the signature upside down. If the letter so treated is a long one, the work of retyping is considerable. In other businesses it is the practice for the

heads of the departments to sign their letters themselves, thus: "For Brown, Robinson & Co., Ltd., John Smith, Sales Manager." Where a clerk or other minor employee is signing for the firm, the signature should read "Brown, Robinson & Co., Ltd., per John Evans," or "For Brown, Robinson & Co., Ltd., John Evans," or "Pro Brown, Robinson & Co., Ltd., John Evans." Very often we see letters signed like this: "Per pro. (or p.p.) Brown, Robinson & Co., Ltd., John Evans," but in most cases such use of the words Per pro. or the initials is incorrect. They stand for the Latin words *per procurationem*, which means "by procuration," and indicate that the person signing has been specially and officially and formally deputed to do so. Unless he has been thus definitely authorised he should sign simply pro or for the firm, as mentioned above.

Copying. The letters having been written, it was the custom years ago, and still is in a few old-fashioned firms, to copy them in a letter book, the pages of which are of tissue. These are wetted, blotted, and then squeezed in a press with a letter in contact with a page of wet tissue, on which the copying ink leaves an impression. This clumsy and unsatisfactory method is rarely used nowadays, letters being duplicated at the time of typing by means of carbon sheets. Of course, any alterations made by the dictator in the typed letters must be transferred also to the copies; and because of the need of this, in some offices carbon copies are not taken. Instead, the letters are copied by one of the patent rotary copiers, several of which are on the market.

Enclosures. When there is to be an enclosure with a letter, the note Encl. is usually typed in the top left-hand corner, but a better system is to stick on the letter a small red disc with the word Enclosure. This is so conspicuous that there is no fear of the enclosure being overlooked.

Envelopes will have to be addressed, and although this may seem to be a simple matter, it is a fact that large numbers of clerks have not the most elementary knowledge of how to go to work. A good letter may be spoilt by a bad envelope. The whole inscription should be nicely centred on the envelope, each line beginning a little to the right of the one above.

The envelope being addressed, the letter and enclosures, if any, next have to be folded and placed inside, and here again a simple operation can be done neatly and well or carelessly.

Stamping. Next the letters are stamped, and in modern offices this is done by means of a stamp-affixing machine, which does many hundreds in a few minutes. Every business should have a properly kept stamp book, in which the quantity of stamps received from the cashier is entered each day on one side, and the name of each addressee on the other, with the amount of his postage. Then at the end of each day the stamp account can be balanced up. The entry of every letter in the book not only makes it difficult to misappropriate the stamps, but the stamp book acts as a useful check on the letters sent out. For instance, if after a week a correspondent says he has not received an answer to his letter, the copy can be looked up as a proof that the answer was written, and the stamp book can be examined under the date of the letter for the name of the correspondent. If the name appears, there it is a proof that the letter was stamped and went off with the other correspondence on that day.

The Perforation of Postage Stamps. Many firms have their stamps perforated with their initials, in order to make misappropriation more difficult. The perforation can easily be done in the office itself by means of a punch sold for the purpose, or the stamps may be bought perforated with any initials from firms that supply them thus prepared.

When letters are sent from any department to the postal department of an office for stamping and despatch, it is a wise precaution to mark an X in the top right-hand corner of foreign letters that may need more than a penny stamp. The meaning of such a sign should, of course, be understood by those who stamp the letters.

Parcels containing fragile objects should have pasted on them small labels bearing in red letters the word "GLASS."

Every correspondence clerk should buy a copy of the official Post Office Guide, which can be obtained at any post-office for sixpence, and make a careful study of the various rules and regulations concerning the postage of letters, parcels, sample packages, and so on. Any clerk who has this useful information at his fingers' ends will soon make his knowledge felt, and be appreciated in any real live business office.

Filing. One other matter in connection with correspondence has to be dealt with, and that is a very important one—the filing of letters received with the copies of those sent out. The old-fashioned method was to stick the letters received in a large guard book, in order of date, and when it was necessary to turn up any letter the book had to be gone through page by page until the needed letter was found. This method has practically died out now. An improvement on this was to fold the letters into a convenient and more or less uniform shape, to endorse on the outside of each the name of the writer, with the date, and sometimes a brief summary of the contents, and then to put these away in order of date in pigeonholes, a separate hole being allotted to each letter of the alphabet.

The modern systems have such tremendous advantages over these old-fashioned methods that it is a wonder they were not originated and adopted earlier. Undoubtedly the best all-round system of filing correspondence is that known as the vertical system. It can be easily adapted to any business, and lends itself to an alphabetical, geographical, or any other arrangement required. The most common way of using the vertical system, however, is that known as the numerical method. Strong manila folders, uniform in size, are numbered from one upwards, and in each folder all the letters from a single correspondent, with copies of all the replies to him, are placed in order of date. The folders are put upright, in numerical order, in the deep drawers of a cabinet

specially built for the purpose. An alphabetical card-index kept in a single drawer or tray enables the number of any correspondent's folder to be found in a moment, and the advantage of the system is that by taking out the folder we have immediately at hand the whole correspondence to and from the particular firm, arranged in order of date. A new folder is allotted to each new correspondent, and is given the number next above the last in the cabinet.

Advantages of the Vertical System. Another great advantage with the vertical system is that, where certain letters will be more easily found under the subject than under the name of the writer, these can be filed with the others and found equally quickly. For instance, letters from firms offering Continental advertising would be difficult to find if filed under their names, as those names are probably unknown, and, in any case, might be difficult to remember. These letters are therefore all put together into one folder, and indexed in the card drawer as Advertising, Continental. If necessary, the letters can be indexed twice, thus, "National French Advertising Company, see Advertising, Continental." Every need and contingency, in fact, is provided for in the vertical system of filing. The value of being able to work several methods of filing together in the one cabinet and index is obvious.

Another way of using the vertical system is known as the alphabetical. This differs from the numerical already described, in that the card index is abolished, and the folders are placed in the drawers of the cabinet in alphabetical order, with guide cards bearing the letters.

The Individual System. Another system of filing in common use is generally known as the individual system. In this the letters are placed in stout manila covers, fitted with metal strips and clamps which pass through holes punched in the letters, and hold them firmly in position. Each cover has an extending linen back, so that the back increases in width, according to the number of letters contained inside. A cover is allotted to each individual firm, and all the letters received from that firm, and copies of letters sent to them, are placed in the cover. These covers are then filed horizontally in cabinets built for the purpose. The system is thus somewhat similar to the vertical, and can be adapted in much the same way.

Box Files. Another method is to have a series of boxes, each fitted with a spring inside to keep down the letters that are placed there. Each letter of the alphabet has a box, the letter being marked clearly on the back, and into this box are placed all the letters the names of the writers of which begin with that letter.

Purse Files. For offices where the correspondence is not very large, a useful file is in the form of a large purse, with separate pockets for each letter of the alphabet. It expands or closes like a concertina, and letters are filed alphabetically in the various pockets. Such files are useful only where the whole of a year's correspondence will go into one of the files. They are convenient also in larger offices as temporary files for letters which are under consideration.

Still another system is to have a series of boards, one for each letter of the alphabet, with two metal spikes on which letters are placed, after having holes punched for the purpose. Clamps then come down, and prevent the letters being knocked off.

Of course, each of the systems described has many modifications, but all letters in modern offices are now filed on one of these principles.

The Sending of Telegrams. This is a very important part of the work of a correspondence department. The wording of telegrams offers fine scope for a man who understands the art of condensation and the importance of economy. Quite a considerable sum of money can be wasted in the course of a year by a large firm through excessive wording in its telegrams. It is well worth the while of a correspondence clerk to practise the art of condensing. Let him take any paragraph from the newspaper, and see in how few words he can express the sense. Of course, clearness of meaning must never be sacrificed to brevity, and it is always better to insert an extra word or two rather than to run the risk of a telegram being misunderstood.

In telegrams, as far as possible, figures and numbers should be written in words; thus, *twenty* is less liable to a mistake in transmission than 20; but, of course, large numbers, such as 25,327, must be sent as figures.

Telegraph Books, Codes, and Addresses. Every telegram sent off should be confirmed by letter the same day, and for this purpose triplicate telegram books are sold by most office stationers. These books usually contain one hundred telegraph forms, numbered from one upwards, and to each form there are two thin duplicate sheets. Carbon sheets are put between the pages, and when the telegram is written the other two copies are made at the same time. The telegram on the form is then sent to the post-office, the first duplicate goes as confirmation to the addressee, and the third is left in the book as a file copy for reference.

Many offices use one of the recognised codes for telegrams and cables, and the name of the particular code used is generally printed on their note-heading, account forms, and the like. A little practice soon enables a clerk to use the code quickly and effectively.

In order to economise the time and money of correspondents desiring to telegraph to them, most business houses now have telegraphic addresses. Any firm can, by paying a guinea a year, register at the General Post Office one word which may be used in telegraphing instead of the firm's name, and, in place of the full address, the name of the town is sufficient address to use with a registered name—thus, "Mistitled, London," can be written on a telegram instead of "Amalgamated Press, Fleetway House, Farringdon Street, London, E.C." The cable companies register telegraphic addresses free of charge. CHARLES RAY

Expansion under Heat. The Calorimeter. Heat of Water and its Effect on Climate. Latent Heat. Evaporation.

HEAT OF LIQUIDS AND GASES

LIKE gases, liquids expand when they are heated—that is to say, nearly all liquids do so. But liquids differ very markedly among themselves in their measure of expansion, whereas we have seen that all gases expand in the same measure. Not only so, but one and the same liquid will expand at very different rates for a similar rise of temperature in different parts of the scale. Water, for instance, at 30° C. expands four times as much for a rise of temperature of one degree as it does for a similar rise at 10° C. Hence it follows that liquids are theoretically quite unsuitable for thermometers. But the reason why spirits and mercury are so constantly used is that within certain limits the expansion of these two liquids is very nearly uniform—sufficiently for ordinary purposes.

Convection Currents. If we take an ordinary liquid such as water and apply heat to a portion of it contained in a vessel, by a spirit lamp, for instance, the heated water rises, since its specific gravity is lowered, and colder water flows from above down the sides of the glass to take its place. Hence we get what are called *convection currents*. The heat is conveyed from one part of the water to another by the actual transit of the heated molecules of water. This mode of the transference of heat is called convection (from the Latin *veho*, I carry) and must be distinguished carefully from the two other ways in which heat is transferred from place to place. Even if the heat were applied to the water from above, so that the hottest water, being the lightest, remained at the top, the water at the bottom of the vessel would gradually rise in temperature. This would occur by the same process as that by which one end of a poker becomes warm when the other is held in the fire. This is the *conduction* of heat as distinguished from its *convection*, and is a very much more interesting matter, which must be studied later. The difference is obvious. In the case of the poker or the water heated from above, the molecules of iron or water do not carry the heat from one place to another, but hand it on. The Gulf Stream is the most striking instance we know of a convection current.

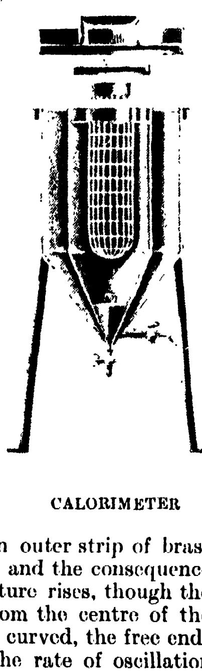
The Peculiar Behaviour of Water. By far the most remarkable facts in connection with the expansion of liquids are those concerned with the very peculiar behaviour of water, which is at its maximum density at a temperature of 4° C., and which expands as it is cooled below this point, so that ice is lighter than water just above the freezing point. We commented on this extraordinary property of water on page 612 and observed its immensely important consequences for human life, and, we might have added, for the life of the fish. But, indeed, this does not exhaust the peculiarities of water in relation to expansion by heat, for Sir James Dewar has demonstrated that ice displays certain peculiarities in this respect, and that when the ice with which we are familiar is cooled below a certain point, there is formed a new sort of ice, which may be called normal ice, and the behaviour of which in relation to heat is similar to that of other bodies.

Expansion of Solids. Solids, also, like liquids and gases, expand with heat, and contract on cooling, though their changes are not so marked. Innumerable experiments may be devised to illustrate the expansion of solids. One of the best of these may be made with a brass ball which is just small enough to pass through a ring. If now the ball be heated, it will no longer pass through until it cools and so becomes small enough. The degree to which a solid expands when heated is susceptible of measurement, and it is found that, as in the case of liquids, solids differ very much among themselves in this respect. Physicists speak of *coefficients of expansion*, and these may deal with expansion in length, which is called *linear expansion*, or with expansion in volume, which is called *cubical expansion*, or with expansion of surface, *superficial expansion*. The consequences of expansion are very important, and sometimes it is of great importance to place together substances which have the same coefficient of cubical expansion. For instance, in the making of incandescent electric lamps, it is necessary to use glass which has exactly the same coefficient of expansion as platinum wire, which is employed simply because it is possible to make glass that exactly corresponds with it in this particular.

Consequences of Expansion. The consequence is that when the lamp is lit, the glass and the platinum expand together. Another illustration may be sought in dentistry. One of the absolute essentials for the successful filling of a tooth is the employment of a filling, usually a mixture of metals, which has exactly the same coefficient of expansion as the tooth itself. When this precaution is not taken, as, for instance, when the necessary details are not properly observed in preparing the filling, the tooth will soon be cracked. If, for instance, one drinks a hot liquid, the filling will expand to a greater degree than the walls of the cavity, and will burst its bonds. On the other hand, if its expansion be too small, it will not expand sufficiently, and, as a result, microbes will make their way in past its sides, or perhaps it will fall out. In various familiar operations some other

consequences of expansion are observed; as for instance, in the heating of tyres so as to fasten them on to wheels, which they grip firmly as they cool; and as in riveting, the rivet is inserted at red heat, and on cooling shortens, so that the plates are held firmly together. Another instance is furnished by the cracking of a tumbler when very hot water is poured into it. The reader who is familiar with the test tubes used in chemistry may wonder how it is possible to boil liquids in such thin tubes when a strong tumbler would certainly crack. The explanation is that the tubes are so thin as to expand equally throughout when heated. But in the case of the tumbler, the inner surface of the glass expands before the heat has had time to reach the outer surface by conduction, and so is apt to split its casing, just like the badly made tooth-filling.

Compensating Devices. The differences of expansion in various metals are of great use. In a good clock, for instance, the pendulum must not consist of one metal because this would expand in summer-time, lengthen the pendulum, cause it to swing more slowly, and therefore make the clock slow. In order to obviate this, there are made what are called *gridiron pendulums*, in which rods of iron and of brass alternate in such a fashion that the expansion of the one in the one direction is compensated for by that of the other in the other direction. Similarly, every good watch has a compensation balance; the balance wheel is not a complete circle but consists of two halves, each of which is just short of a semicircle. These halves consist of an outer strip of brass and an inner strip of steel, and the consequence is that, when the temperature rises, though the strips tend to move out from the centre of the wheel, they become more curved, the free ends turning inwards. Thus the rate of oscillation of the wheel is not retarded.



CALORIMETER

The Measurement of Heat. Literally, a thermometer is a heat measurer, but we have already seen that the thermometer merely measures heat level, and that only under certain very definite conditions does the thermometer serve as an index to the amount of heat in a body. In order to measure heat, we must have a unit, and the unit of heat, or thermal unit, is that amount of heat which can raise one gramme of water from 4° C. to 5° C. This amount of heat is technically known as a *calorie* (from the Latin *calor*, heat). This is the only unit of heat we need now consider, as it is now in universal use. The fact that makes it necessary to specify the temperature of the water was noted at the beginning of our discussion. It takes more heat to raise the unit mass of water through one degree, from 80° C. to 81° C., than from 4° C. to 5° C.

Specific Heat. Now, we have also seen that in the case of water and mercury we require to put far more heat into the water in order to cause a given rise of temperature than into the mercury, and this gives us a clue to the meaning of what is called specific heat. This is best defined as the number of calories or units of heat necessary to raise a unit mass of a substance through 1° C. Thus the specific heat is really a measure of the capacity for heat of any body. Now, in order to study this subject, we obviously need more apparatus than a mere thermometer, and the apparatus employed is called a *calorimeter*. This essentially consists of a box containing a thermometer and a quantity of water. This box, usually made of thin copper, is placed in other boxes and is carefully supported on props in such a way that no heat can get out of it, and the thermometer is carefully fixed in the handle of a stirrer which passes through a hole in the cover of the calorimeter. If we now place inside the calorimeter any body at a given temperature, the thermometer will readily enable us to ascertain the amount of heat which such a body has been able to impart to the water of the calorimeter—the amount of which is, of course, known.

The Specific Heat of Water. Another remarkable peculiarity of water is that it has a very much higher specific heat than any other known substance. This being so, its specific heat is taken as *one*, and the specific heat of other substances is stated proportionally. In general, the metals have low specific heats; those of brass and copper, for instance, are less than one-tenth that of water. On the other hand, the specific heat of alcohol and glycerine is more than ·6 and that of ether is more than ·5. The consequences of the high specific heat of water are almost as striking as those which follow its peculiar behaviour as regards expansion near its freezing point. In the first place the high specific heat of water means that a given quantity of water at a given temperature contains more heat than a similar quantity of any other substance, and, in cooling, such a quantity of water necessarily gives out more heat than any other substance, just as, in raising its temperature, more heat had to be put into it. Hence, for warming purposes, water is the most valuable agent. A hot bottle filled with mercury, for instance, would be quite cold in a very small fraction of the time required to cool a hot-water bottle; and it is this property of water which makes it so useful in hot-water pipes.

Water and Climate. This property of water also profoundly affects the climate, for it tends constantly towards equalising the temperature. In summer the water does not have its temperature raised so quickly as the land, its specific heat being so much higher. This means, of course, that at night heat will

tend to flow to the sea from the land, the temperature of which is thus kept down. But in winter the land rapidly loses its comparatively small store of heat; the sea, however, is able to supply it from its own plentiful store, and thus the climate is made more equable, the summer milder, and the winter less cold. These are the characteristics of an insular climate such as our own, and they are of the utmost value. The relatively cool summer that depends upon the high specific heat of the water surrounding us, tends to set some poor bounds to our terrible infantile mortality, which depends mainly upon the bacterial decomposition, under the influence of heat, of milk and other food; and the relatively mild winter, due to the same cause, tends to keep down the death rate from pneumonia, bronchitis, and other diseases of the lungs. We abuse our climate, but it is one of the best in the world; for it has not only the advantages of an insular climate, due to the high specific heat of water, but is also ameliorated by that great convection current which is called the Gulf Stream, and which constantly carries to us quantities of heat from the tropics.

Though all other liquids fall far short of the specific heat of water, they have higher specific heats, as a rule, than solids; and it is also the rule that the specific heat of a substance is higher when it is liquid than when it is solid. The specific heat of ice, for instance, is only one half that of water: this being an instance of the general proposition that the specific heat increases with the temperature of a substance.

Latent Heat. Another of the most striking effects of heat is its power of changing the physical state of matter. This has already been discussed at some length in relation to the kinetic theory of gases and molecular motion. We know that there are three well-recognised states of matter and that these differ essentially in their measure of molecular motion; and we have seen also that heat and molecular motion cannot ultimately be distinguished from one another. Suppose we melt some ice at the freezing point; the temperature of the ice was 32° F., the temperature of the water formed when the ice melts is also 32° F.; what has become of the heat we employed in melting the ice? We must believe that it is represented by the more active molecular motion of the water, and this heat, or heat that was, is now called latent heat. In this particular case it is the latent heat of fusion (or melting). This may be defined as the number of thermal units required to change one unit of mass of a solid into a liquid without changing its temperature.

Determination of Latent Heat. Latent heat was first discovered by that remarkable genius, Joseph Black, who was mentioned in the second chapter of the course on CHEMISTRY. He determined the latent heat of water by what is called the *ice block calorimeter*. A ball of metal heated to a known temperature is inserted into a hole of a block of ice, the hole being covered with a slab of ice. The metal is gradually cooled until it reaches the freezing point, and in doing so it melts a quantity of the ice. The water thus formed is poured out and weighed. If we know the weight of the metal, and its specific heat and its temperature when it was inserted, we know the number of calories necessary to convert into liquid a quantity of ice corresponding to the weight of the water that is formed. Another method that may be employed consists in the insertion of a known quantity of ice into a calorimeter.

When we spoke of the Fahrenheit scale, we referred to the mixture of ice and salt, which provided Fahrenheit with the lowest temperature that he could obtain. Such a mixture is called a freezing mixture, and everyone who has made ices at home is familiar with it. The ice tends to melt, but in doing so it is compelled to obtain from its neighbourhood the amount of heat represented by the latent heat of water. As it melts, it dissolves the salt and thus forms brine. Now the freezing-point of brine is very much lower than that of water. Hence, such a mixture will readily freeze the mixture of milk, water, and so forth, of which ices are made.

Again, we find that water is distinguished in respect of its latent heat, which is about 79° C. That of iron is 23, of lead 5·3, and of mercury 2·8.

Temperature and Expansion. Our discussion of molecular motion in a previous chapter will enable us to believe that a change of volume is usually observed at the melting point, and we should rather expect that when a solid melts it should occupy more space than formerly. In the case of water, however, as also in the case of various metals, such as iron and lead, the solid occupies more space than the liquid at the freezing point. This is why cold cracks the water pipes. The water appears when the thaw comes, but that does not imply that it is the thaw which breaks the pipes; the pipes were broken with the frost, which solidified the water and caused it to expand, thus bursting the pipes; the thaw merely demonstrates the consequences.

Having observed how the question of pressure must always be correlated with that of temperature—as, for instance, in Boyle's law—we shall be prepared to believe that pressure affects the melting point; and this is so. In general, the bodies which contract when melting, melt more easily—that is to say, at a lower temperature—if pressure be applied to them. This is evidently reasonable, since the pressure tends to make them contract. Conversely, bodies which expand when they melt naturally melt with a greater difficulty under increase of pressure.

Regelation. These facts account, in the case of water, for the exceedingly important phenomenon called *regelation*. If a weighted wire be passed across a slab of ice, its pressure will cause the ice to melt, so that it gradually cuts its way through the slab, leaving, however, not an open track, since the water easily freezes again as soon as the pressure of the wire is removed. Similarly, if two slabs of ice are pressed together, and then the pressure be removed, they are found to have become continuous with one another. The pressure caused the surfaces in contact to melt, and when it was

removed they froze together. It is now believed that this phenomenon explains the motion of glaciers [see GEOLOGY]. Hence, though ice is a solid, it yet moves down a glacier valley almost as if it were a viscous liquid. For the ice which is in contact with the bed of the glacier is constantly being induced by the pressure above it to melt and then freeze again in a fresh position, thus enabling the whole slowly to move on. Therefore we must regard the motion of glaciers as mainly dependent upon the influence of pressure upon the melting point of water.

Liquids and Gases. Just as the addition of heat causes solids to liquefy, so it causes liquids to evaporate or become gaseous. If we take the case of water placed in a saucer, we find that it ultimately disappears; it has evaporated. Even ice evaporates without first passing through the obviously liquid stage. The converse process we call condensation, and every child who has looked through a pane of glass on a cold day is prepared to understand that the gaseous water which has left his lungs has become liquid by contact with the cold glass. Now, questions of evaporation and condensation are determined largely by pressure as well as by heat. We have said that water, and even ice, evaporate at all temperatures. But if the air above the water were already saturated with water vapour, no more water would be evaporated. Thus the evaporation of water depends not only upon temperature, but also upon the pressure of water vapour. But this pressure varies at different temperatures, so that, here again, we have pressure and temperature correlated. Saturated water vapour increases its pressure as the temperature rises. When the temperature falls some of the vapour is condensed, and the pressure is less.

We often talk of volatile liquids, and the term may be used to imply those which are very readily evaporated at ordinary temperatures, having a large vapour pressure. Conspicuous amongst these are ether and alcohol, which have a much higher vapour pressure than that of water. Some liquids, however, cannot be evaporated at all, and so the term volatile may be applied to all the others. The two uses of the term are unfortunate.

Vapours. We must carefully distinguish between unsaturated and saturated vapours. The former are simply gases, and obey Boyle's law. Of the latter, the following law may be stated: *The saturated vapour of every liquid that forms a vapour exerts a certain pressure, differing with various liquids, at a given temperature, and this is always the maximum pressure which it can exert at that temperature.*

In the case of every gas there is a temperature which is called the *critical temperature*, and as long as it is above this point no amount of pressure will cause the gas to liquefy.

We must now also formulate the law frequently referred to in relation to the partial pressure of the carbonic acid gas and other constituents of the atmosphere. It is that *in a mixture of vapours and gases*—as, for instance, in the case of air, which always contains a quantity of water vapour—*each constituent exerts its own pressure independently of the other, provided that there is no chemical action between them.* This fact may be expressed by saying that, so far as the pressure of the water vapour is concerned, the air acts as a vacuum towards it—"one gas acts as a vacuum to another."

Evaporation and Boiling. In both these processes there is the transference of a liquid into the gaseous state; but in the case of the former, it is necessary that, for the vapour to form at the surface of the liquid, the space above it *be not saturated*; whereas, in the case of boiling, the vapour is discharged into saturated space, being formed at the temperature of saturated vapour at the pressure in the liquid. Thus we may define the boiling point of any liquid as the temperature of saturated vapour at the pressure in the liquid. Water vapour at any given pressure must have a definite temperature, and the pressure of a bubble of water vapour, formed when water boils, must at least equal the fluid pressure outside it; otherwise, plainly, it could not maintain its bubble form.

Therefore, at the ordinary atmospheric pressure, the bubble of water vapour formed in boiling water must have a temperature of 100° C. Bubbles may be formed at the bottom of the kettle, for instance, before the water reaches this temperature. Such bubbles, however, cannot rise unchanged through the liquid, but are condensed when they reach the surface. It is not until the whole of the water has reached the boiling point that the bubbles formed below can pass unchanged through the liquid, and it is not until we see this occur that we can declare the liquid to be boiling. As the heat continues to be applied, the temperature of the remaining liquid is not increased, but all the heat is used up in converting part of it into a vapour.

Boiling under Various Pressures. In the case of ordinary boiling water, the external pressure is simply that of the atmosphere, but we are now able to understand that if the atmospheric pressure be altered, the boiling point must be correspondingly altered—that is to say, the vapour of the liquid escapes when the water is at the temperature corresponding to the external pressure. If, then, we lower the external pressure, the boiling point is correspondingly lowered—that is to say, the vapour can be given off freely at a lower temperature than before. This fact provides us with a more or less accurate means of determining heights. For if we boil water on a mountain, a thermometer will indicate the new boiling point, and from the degree to which this has been lowered we can infer the lowering of the atmospheric pressure, and thus the height at which the reading is taken. A consequence of this fact is that on the tops of high mountains cooking is performed with difficulty. For instance, it is impossible to cook an egg at a height so great that the boiling point of water is below the temperature at which the white of an egg coagulates or solidifies.

But, just as the pressure is lowered by ascending a mountain, so it may be raised by boiling in some sort of a vessel which does not permit the vapour to escape readily. In such a case, the external pressure is much higher than that of the atmosphere, because the partially confined steam exerts a pressure upon the surface of the liquid. We are now prepared to accept the fact that in such a case the boiling-point is raised.

Latent Heat Again. When discussing the liquefaction of ice, we made the acquaintance of latent heat, and saw that in the act of converting ice at freezing-point into water at the same point, much heat was employed, though there was no rise in temperature. This we called latent heat of fusion. Similarly we find that when a liquid is converted into a gas a quantity of heat is absorbed, and this we call latent heat of evaporation. It is the heat which disappears —needless to say, it is not annihilated—when liquid at the boiling-point is changed into vapour at the same temperature. The heat is still there, but it cannot be perceived by the senses ; it lies hidden, and hence is called latent (Latin *lateo*, I lie hid), whereas the heat which can be perceived, or "sensed," is called *sensible heat*.

Washing without a Towel. If we wash the hands on a cold day and allow them to dry without a towel, we soon discover how cold they become—so cold that the skin is apt to be injured, and the hands become chapped. Why should the evaporation of the water from the hands cause them to become cold ? The reason is evident. The latent heat of evaporation has to come from somewhere. Whenever any part of a liquid evaporates, some sensible heat must become latent. And in this case the heat is derived from the hands. The additional energy of molecular motion which the water vapour possesses in virtue of its more active molecular motion is obtained by the transformation of sensible into latent heat, and the heat in our blood has to pay the penalty. The more rapid the evaporation, the greater is the reduction of temperature of the body from which it occurs.

Hence, alcohol, ether, *Eau de Cologne*, and similar substances, are used in preference to water for relieving a headache, or reducing the temperature of a hot and painful area of skin. These facts also explain our objection to wetting the feet. As the footgear dries, the latent heat of evaporation of the water has to be obtained from somewhere, and the feet pay the penalty. But we have already seen that the rate of evaporation, or its possibility at all, is determined by the amount of vapour already present in the air. When the air is saturated, it can hold no more, and evaporation ceases. Hence, the importance of a current of air in the process of drying anything, and hence the danger of a current of air, or a draught, in causing the perspiration to evaporate too rapidly, and thus lowering the temperature of the body.

Water Vapour and the Weather. Just as changes of pressure affect the boiling-point, so they affect the speed of evaporation at any given temperature; and, as we should expect, evaporation is hastened by decrease of pressure, and is retarded by an increase.

When discussing the atmospheric pressure, we described the barometer, and showed how it may be used as a weather-glass, the inference being that the state of the atmospheric pressure at any given time and place is the most important fact in determining the kind of weather experienced there.

But it is also very necessary, in order to understand the weather, to recognise the part played by water vapour in the air in affecting our sensations, and the obvious characters of the weather. This subject may appear to be a mere digression from the great subject of heat which we are discussing, but we must remember that temperature is one of the conditions which determine the amount of water vapour in the air, and also that the difference between such water vapour and the liquid water which we know as rain depends upon the latent heat, so-called, which is contained in the former.

Water and Air. Water vapour is a constant constituent of the air, but its amount varies within very wide limits, and its amount may be expressed by the term, *the humidity of the air*. So long as the air is not saturated, it has a drying power, as everyone knows, and we have already noted that the motion of the air aids this drying power simply because it interferes with the tendency toward saturation. What we constantly appreciate by our senses is not the absolute humidity of the air—that is to say, the actual quantity of water vapour which it contains—but its relative humidity, which may be defined as the ratio of the actual density of the water vapour in the air to the possible density at that temperature—that is to say, the density of saturated vapour. Hence, on a hot day we would call air dry which really contained much more water vapour than the air which, on a colder day, we would call damp, the reason being that, in the first case, the air was much farther from saturation-point than in the second case, and thus was, though absolutely much more humid, relatively less humid, and so possessed of much greater drying power.

We have already seen that in a mixture of vapours and gases each constituent exerts its own pressure independently of the others. The pressure of the water vapour in the air is thus exerted just as if nothing but water vapour were present. It depends upon its quantity and upon the temperature. When the temperature is lowered beyond a certain point some of the water vapour in the air is condensed in the form of dew, and that point is called the *dew-point*. This depends upon the pressure of the water vapour, and we have already seen upon what conditions this pressure depends.

Hygrometers. The *hygrometer* (Greek *hygros*, damp) must carefully be distinguished by the student from the *hydrometer*, which we have already described as an instrument for measuring the specific gravity of a liquid. The object of the hygrometer is to determine the humidity or dampness of the air, and this is

usually done by determining the dew-point. The best-known hygrometer is named after Daniell. It consists of a bent-glass tube with a bulb at each end, one of which is half full of ether that has been boiled, so that the whole apparatus contains nothing but ether and ether vapour. The bulb containing the liquid ether also contains the thermometer, and is blackened. The other bulb is covered with cotton-wool, upon which a little ether is poured. This rapidly evaporates, and in order to obtain its latent heat of evaporation it is bound to condense the ether vapour within the bulb. This permits further evaporation of the liquid ether in the other bulb, which, for the reason we are now familiar with, is also lowered in temperature. When the temperature falls to a certain point, dew appears on the blackened surface of the other bulb. Thus the dew-point can be ascertained. But the most accurate way of using the hygrometer is not to be content with one reading, but to note it, stop the cooling process, and then carefully note the temperature at which the dew disappears. The mean of the two readings is the dew-point.

Wet and Dry Bulb Thermometer. This is a thoroughly useful device so long as we remember to keep it supplied with water. In the first place, there is an ordinary "dry bulb" thermometer, which ascertains the temperature of the air. Beside it, there is another, the bulb of which is covered with muslin, which is kept wet. This is usually done by attaching a piece of lamp-wick to the muslin, along which, by capillarity, water travels from a reservoir. The rate at which the moisture evaporates from the muslin is an index to the relative humidity of the air—that is to say, to its drying power—and can itself be measured by the extent to which it lowers the reading of the wet bulb as compared with the reading of the dry bulb thermometer.

Needless to say, there are simpler methods than any of those for ascertaining, very roughly, not the absolute amount of moisture in the air but its relative humidity. For instance, there is the *hygroscope*, the essential part of which is simply a human hair, which is longer when moist and shorter when dry. A piece of seaweed, also, containing a quantity of salt, acts as a hygroscope, because when the air is near saturation point it becomes soft, whereas when the relative humidity of the air is low it becomes hard.

Relative Humidity and Health. The relative humidity of the atmosphere is a very important factor in our bodily comfort and health. The temperature of the warm-blooded animal body must be kept constant at all costs, and this is effected by a balance between the rate at which heat is produced within the body and the rate at which it is parted with to the environment. We lose heat to the environment in two ways; in the first place, by direct *radiation*—a term to be later explained; and in the second place, by supplying the latent heat of evaporation to the perspiration, sensible and insensible, which is incessantly leaving the body. The possibility of controlling the temperature in the latter fashion entirely depends upon the relative humidity or drying power of the air, which is thus a far more important factor in our comfort than its mere temperature. The temperature is important in so far as it helps to determine the amount of water vapour which the atmosphere can hold than in any other way. When the amount of water vapour in the atmosphere is nearly at saturation point, the evaporation of the perspiration becomes very slow, and hence our discomfort.

Dew. When we spoke of the hygrometer, we observed that the commonest means of ascertaining the relative humidity of the air consists in an observation of the dew-point. It is commonly stated that the natural formation of dew takes place in a precisely similar fashion to the formation of dew on the other bulb of Daniell's hygrometer. At night, the warm earth rapidly radiates into the atmosphere the heat that it has received from the sun during the day, and blades of grass and the like, standing slightly apart from the earth, become especially cool, and cool the air in their neighbourhood, so that it can no longer hold the moisture which it could hold when it was at a higher temperature—in other words, it is cooled below its saturation temperature, and deposits its moisture. One of the most important factors in determining the amount of dew that falls is the rapidity of the radiation that occurs when the sun goes down, and this is favoured on a clear dry night, while, if the night be also still, the formation of dew is still further favoured, the lower layers of air having time to deposit their moisture before they are blown away. No doubt this is substantially true, but the botanists tell us that plants constantly perspire (though the technical term used is *transpiration*, which is the French equivalent for our word *perspiration*), and it seems more than probable that a portion, at any rate, of the dew does not consist of moisture deposited on the leaves of grass from the air, but consists of the water which has passed out from the leaves themselves, and the evaporation of which is prevented owing to the cooling of the surrounding air below its saturation temperature, in the fashion we have explained. Of course, the old explanation still holds entirely true for the formation of the dew elsewhere than on plants. When dew freezes, it produces hoar-frost.

Fog. Where the radiation at sundown is extremely rapid, and where the air contains a very large amount of moisture, as, for instance, in tropical forests, where the dew is formed above the tree-tops, it falls like a shower of rain. This introduces us to a new subject. We have already seen that there is always a certain amount of water vapour in the atmosphere. A cloud also consists of water, but it is liquid water, formed by a lowering of the temperature of a mass of vapour-laden air, and thus having the same essential causes as dew. If the cloud be near the ground, we do not call it a cloud, but a mist, and if this be at all dense we call it a fog, whether it be pure or the filth-laden gloom in cities.

C. W. SALEEBY

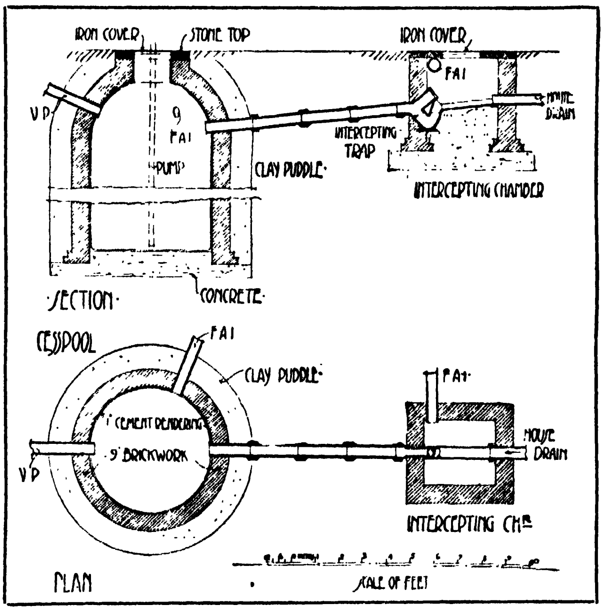
Special Requirements and Practice. The Failure of Traps. Drain Ventilation. Drain Testing and Cleansing.

DRAINAGE OF COUNTRY HOUSES

In the drainage of country houses some features not met with in towns provided with sewerage systems are introduced. The first of these are *sumps*, or *soakaways*, for rain-water. They may be employed when it is not desired to store the rain-water. Such a sump consists of a pit which is sunk in the soil, and which should have a capacity of at least one cubic yard, and should be filled in with hard, dry, clean brick or stone rubbish; it should be at least 6 ft. from the building, and a drain is taken from the foot of the rain-water pipe, so as to deliver the water into the sump. A small chamber may be formed with bricks laid dry around the end of the pipe, to ensure that it is not choked up by the smaller material. Each pipe may have its own sump, or two or three may deliver into one. In dry, porous grounds the size may be kept small, as the water will rapidly disperse by percolation, but in moist and clayey soils the capacity should be large. The actual size will depend upon the amount of water delivered by the pipe; no sump should be formed for this purpose so deep as to reach the level at which water stands naturally in waterlogged ground. Wooden butts are often used to receive the rain-water delivered by a single pipe, but should have an overflow and a drain placed under the draw-off tap which is usually provided.

Cesspools. Cesspools are large receptacles sunk below the ground-level for the reception of sewage. They are of two classes, both generally circular in plan. Those usually required are made watertight, with the bottom of cement concrete, walls and domed top of brickwork set in cement; or the wall and dome may also be in concrete. The interior is rendered in cement and sand [see PLASTERER], and in damp situations the outside may be surrounded with *clay puddle* [see ENGINEERING FOR WATER SUPPLY]. The top has an opening closed with a manhole cover and a perforation for the suction-pipe of a pump, if one is used for pumping liquids only. [48]

The drain which delivers into the cesspool has an intercepting chamber close to it. The cesspool, which should be placed at least 100 ft. from any dwelling, has a F. A. I. and a V. P. carried up a tree or a tall post. Nothing should be led into it but the soil-drains from closets and the scullery sink. The size varies with circumstances; but even a large cesspool, if it has no outlet or overflow (and this is not as a rule permitted), will require pumping out at frequent intervals.



48. CESSPOOL AND INTERCEPTING CHAMBER

The second variety of cesspool is similar in form, but is built dry—*i.e.*, the bricks are laid without mortar. In chalk it may be excavated in the chalk, and remain unlined. Its construction allows the liquids to percolate into the soil, and is only suitable for dry, porous soils in situations where there is no danger of contamination of any source of water supply. Into such a cesspool all wastes, as well as soil-drains, may be taken, and if capacious it will require cleansing only at long intervals. The intercepting chamber and system of ventilation is required, and a small cesspool of this type is sometimes provided for bath and lavatory wastes where the soil-drains are taken to a watertight cesspool.

Storage Tanks for Rain-water. These are employed where separate rain-water drains are used. They are constructed underground in a manner similar to watertight cesspools, but

of much greater capacity. The actual size is regulated by the area from which rain-water is collected and the rainfall of the locality. For every square of 100 ft. of roof drained a provision of 8·3 cubic ft. must be made for each inch of rainfall to be stored, and about half this amount from paved yards. The average rainfall throughout England is about 2½ in. per month but varies considerably in different districts and in different months. Where it forms the only source of supply the capacity for the tanks should be equal to storing four months' supply.

Storage Tanks. The tank [49] may be circular or rectangular, and is sometimes lined with asphalte. [See BRICKLAYER.] It may be provided with a small catchpit and strainer to receive the end of the drain, and to retain any solid matter It must have an overflow, which, if possible, should be taken to a ditch or pond; if taken to the soil-drainage system it must be efficiently disconnected. The tank must have a manhole cover for access, and a lift or force-pump for raising the water to the cisterns supplying the house. The pump must be connected to the well with a suction-pipe, taken down nearly to the bottom of the well, and to the cistern by a delivery pipe. Pipes and cisterns for rain-water should be of iron, not lead, as the rain-water attacks lead.

Subsoil Drainage. Subsoil drainage is required for draining off stagnant subsoil water due to general saturation or to a land spring. The drains are laid with the agricultural drains already described. Pipes of 3 in. diameter are usually employed; a series of parallel trenches are cut, the drains laid in the bottom, and the trenches filled in. The depth of the trench varies with the nature of the soil, from 2 ft. to about 4 ft. 6 in.; the distance apart of the trenches varies usually from 12 or 15 ft. in stiff ground, to from 30 to 40 ft. in loose, porous ground. The trenches when close are kept shallow, and increase in depth as they are spaced further apart.

The ends of the pipes are connected to a 6 in. or 9 in. socketed drain, and taken to a ditch or pond. The outfall should be open to inspection, but closed by a wire grating against vermin. Such drainage may be laid with very little fall, but any general inclination of the ground surface should be followed, where possible, the outlet of the main cross drain being at or near the lowest level of the land to be drained.

Failure of Traps. Conditions arise when the traps previously described may cease to be efficient. The arrangement of a good drainage system should be such as to minimise the effect of their failure. The principal causes of failure in traps are the following:

1. The water-seal may be *forced* by an accumulation of gas on the sewer side if the pressure is sufficient. This most frequently happens with the main intercepting trap from the collection of gases in a sewer. It should not happen with gullies if the ventilation of the drains is well arranged and kept efficient.

2. The water in the trap may be *evaporated* in dry weather to such an extent that the seal ceases to exist. This happens most often to gullies provided to receive surface drainage only from small areas. Such areas are often placed directly under basement windows, and, if a gully placed in one of these becomes inefficient, sewer gas is liable to enter the building through the window. A gully in such a position should have, if possible, a lavatory or sink waste taken into it. This will keep it charged if in frequent use. If this is impossible, the most certain method of protection is to take the drain from the gully, not directly into the main drain, but into another gully which does receive such a waste, and will not, therefore, be liable to dry up even in a prolonged drought. Gullies are not desirable, and, as a rule, are not permitted, in the interior of buildings. If used in any case, the drain from such a gully should on no account be connected with the general drains directly but must be disconnected as already described.

3. The contents of a trap may be *syphoned out*. This is caused by the creation of a partial vacuum on the inner side of the seal, produced by a full-bore discharge in a neighbouring pipe. The pressure of the air on the upper side of the trap may then suffice to drive before it the water standing in the trap and force the seal, which remains open till the trap itself is recharged. This affects the small traps of sanitary fittings more seriously than gullies, and will be referred to again [see INTERNAL PLUMBER], but the condition may arise in gullies.

4. The contents of the trap may be carried out by the force of *momentum*. When a considerable full-bore discharge takes place the whole body of water may pass through the trap without leaving a sufficient quantity in the trap itself to complete the seal. This is very liable to happen in the discharge of a flushing tank or cistern, and most flushing rims are constructed so as to retain a sufficiency of water to recharge the trap after the main flush is completed.

The Placing of Gullies. It is necessary, therefore, to bear in mind the possibility of the failure of traps, and, in planning drainage, to avoid placing gullies in positions where, in the event of such failure, sewer gas will readily find its way into the building. One useful means of reducing the liability to this danger is to place the gully not directly under the pipe, but at a distance of about 18 in. from it. The pipe is arranged to discharge into an open channel, which may be formed in concrete and lined with cement, or with a half-round channel; but the most complete form is the *slipper gully* [34, page 1001]. This is an ordinary gully fitted with a special form of top, including the channel, which is adapted at one end to receive the discharge of one or more pipes, and at the other to deliver the contents into the gully. When fixed, it should have a galvanised-iron grating or wire cover to prevent choking with dead leaves or rubbish.

Ventilation of Drains. An essential feature of a good drainage system is efficient ventilation, which is required to prevent the

accumulation of dangerous gases in the system and to ensure that any gas generated in it or entering it from the sewer may be discharged in such a manner as to be innocuous. Briefly stated, the system consists in providing an inlet for fresh air (F. A. I.) on the house side of the intercepting trap, the construction of which has been already described ; and to provide at or near the head or highest part of the drainage system an outlet, which is carried up well above the highest window or other opening into the building, or, better still, to the ridge of the roof. It is not desirable to carry it up a chimney stack, and in no case should it terminate at the level of the top of a chimney flue. When there is no fire in the fireplace below, such flues often act as inlets to the building, and may suck in the gases that we have been at great trouble to exclude from the building. Between the inlet and outlet there must be nothing in the way of a trap or other obstruction to impede the circulation of the air.

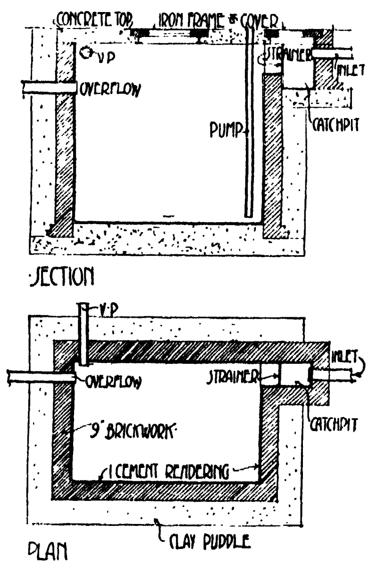
Ventilating Pipe. The ventilating pipe (V. P.) [see PLUMBER] may be a pipe of lead or iron specially erected, but if the soil-pipe from a w.c. occurs within 10 ft. of the head of the drain it may be utilised. Every soil-pipe ought to be treated as a ventilating pipe wherever it occurs in the system. The soil-pipe is cut off from the interior of the house by the traps of the w.c. apparatus [see INTERNAL PLUMBER]. The V. P. is connected at its bottom end to the drainage system, and is carried up, without any reduction of its diameter, as straight as possible. All unnecessary bends must be avoided, and the top finished with a fixed dome or globe formed of copper or galvanised iron wire to prevent birds having access and building in it nests, which would destroy its utility.

In some cases an exhaust cowl is added to the V. P. to assist in extracting the air. The pipe should be fixed against a sunny wall if possible, for in such a position the sun will heat the pipe and the column of air within it will be heated, rarefied, and tend to rise, setting up a natural current of air in the pipe, while cool air will be drawn in through the F. A. I. to replace it. But under some conditions this action may be reversed, and it is on this ground that the head of the F. A. I. is provided with a self-closing flap. Lest this should fail, the position selected for the inlet should be such that if for a time it forms an outlet no serious harm may be done. It is best placed as far as possible from any opening into the building.

So long as such a ventilation system operates, it is impossible for any serious pressure of gas to be created in any part of the drainage system, so that the danger of the seal of the gullies being forced is obviated, and if the interceptor is forced the sewer gas has a free road to escape above the roof level.

Testing Drains. The laying of the drain in straight lines and to true falls should be watched during its progress ; it may be tested on completion by placing a small mirror in the invert of one manhole and a lamp or candle in the next ; even a sheet of white paper will serve in place of the lamp if the manhole cover is open. When truly laid the orifice at the distant end will appear in the mirror truly centred in the near orifice.

Water Test. The test for soundness—that is, the capacity to retain without leakage liquids passing through or standing in the drain —is made by charging the drain with water. It is usual to test each length of drain separately as laid, and later to test the whole system or considerable sections of it, including the manholes.



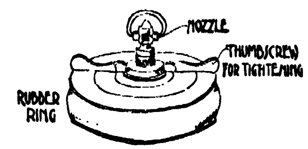
49. RAIN-WATER STORAGE TANK

Drain Plug. For each individual length the lower end of the drain where it enters a manhole is stopped by means of a *plug* or *stopper*. There are two principal classes of these. One consists of two metal plates, the edges arranged to form a V joint, and capable of being adjusted by means of a screw [**50**]. In the V is placed a thick ring of rubber circular in section. When the plates are separated the diameter is slightly less than that of the pipe to be tested, and it can be placed in the mouth of the pipe. On turning the screw the plates are drawn together, the width of the V joint reduced, and the rubber band, forced into contact with the surface of the drain at all parts, closes the drain completely. Where a considerable pressure of water is to be used, it is useful to strut this plug from the opposite side of the manhole, or it may be blown out bodily by the pressure. Through the centre of the plug an outlet of small diameter is formed, with a tap or screw cap by which it may be closed or opened. This is used for allowing the water to escape after the test is completed. There is also a loop or ring to which a cord or chain may be attached to prevent the plug being washed down the drain if accidentally displaced.

Air-Bag. The other form of plug consists of an *air-bag* [**51**]. This is placed in the mouth of the drain, and air is pumped into it with an inflator till it swells and closes the orifice. It is held in position solely by friction

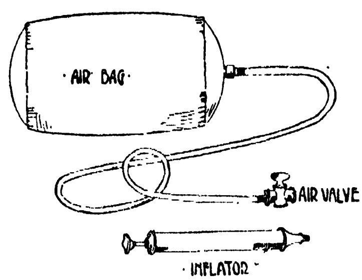
between the bladder and the pipe due to the air pressure within.

The outlet having been closed, the pipe is completely filled with water from its upper end. If the length of pipe is short and the fall slight, a bend may be inserted in the end and turned up so that the level of the water standing in the bend should be about 5 ft. above the level of the outlet. With long runs and fairly rapid falls the head of water in the pipe will be sufficient, and with very rapid falls the head of water may be excessive, but it should not be allowed to exceed 10 ft.



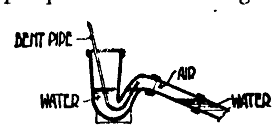
50. DRAIN-PLUG OR STOPPER

Filling the Drain. The filling is best done by a rubber hose, and care should be taken to prevent any water passing into the trench. When the pipe is fully charged the water-level is noted, which may be done by a 2-ft. rule. A convenient plan is to use a strip of white paper, which may be dipped into the water and then stuck against the side of the pipe or gully so that the lower edge just touches the water. If the water remains in contact with the paper without perceptible movement for 20 to 30 minutes the drain is sound. If the water is observed to fall very slightly in the pipe it may be due to absorption by the cement in the joints, and a fresh observation must be made. If the water sinks at all rapidly, or continuously, all the joints in the drain must be examined to find the joint or joints that are defective, and any defective joint must be made good and the test again applied.



51. AIR-BAG AND INFLATOR

Withdrawing the Air. If the upper end of the pipe is formed by a gully or by the pan of a water-closet it is necessary to see that the air is withdrawn from the upper part of the trap, or it will be impossible to fill the pipe. This may readily be done by passing a piece of bent lead pipe—½ in. will suffice—under the seal, so that the inner end penetrates to the upper part of the outlet [52], giving a communication with the air outside and allowing the air in the pipe between the stopper and the water-seal to escape as the water rises.



52. WITHDRAWING AIR FROM GULLY OR W.C. TRAP

When all the pipes converging into one manhole have been found sound, the plug is inserted in the outlet of the manhole, and the manhole and the pipes entering it can be tested together, and, if necessary, by stopping off the various inlets, the manhole can be tested alone, but it is difficult in this case to be sure that all the plugs are perfectly watertight.

This test may be relied upon to disclose any defect in the pipes, jointing, or manholes; such a condition may actually arise in any drainage system should the intercepting trap or the outlet become blocked through any temporary cause, so that it is not an unduly severe one.

Smoke Test. The smoke test is usually applied to new drainage systems to ascertain that the ventilation is in proper order. The test for this purpose may be made with a smoke rocket. This is simply a stout paper cartridge filled with a special preparation which, on being ignited, emits a dense and very pungent smoke. It may be lighted and placed in the intercepting chamber, the lid of which must be at once closed. After a very short interval the smoke should be seen to issue from the top of the ventilating pipe, while none should be seen or smelt at the fresh-air inlet.

This test is also used for testing the soundness of the joints of the lead and iron pipes within the building [see PLUMBER], for if any of these are in the least defective, the very pungent smell of the smoke will be at once detected. In this case the observer should on no account personally light the rocket, as, if he does so, his nose may not, after smelling it in the manhole, be sufficiently sensitive to detect it in the building. Care must also be taken to see that all doors and windows are closed, and that the smoke, if any escape from the manhole, is not admitted directly to the building at any point. In making this test every room in which there is any fitting connected directly or indirectly with the drainage system should be visited.

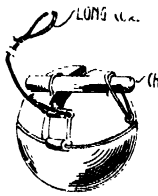
This is a useful test to apply to drains and fittings that are not new, and the soundness of which is uncertain. For either purpose the smoke is sometimes generated in a special box, and forced into the drain under pressure by means of an air-pump. This ensures a slight pressure in the system, and adds to the utility of the test, but it is not necessary when the ventilation alone is to be tested.

Although the plumbers' work in fitting up w.c's and other apparatus will be dealt with later, another method of testing the soundness of internal joints may be here dealt with. It is used chiefly in connection with w.c's.

Ferrets. *Ferrets* are made of different varieties by different manufacturers, but the object of all is to introduce into the pipe behind the trap a charge producing a very strong pungent smell which cannot return through the trap, and which, if it is detected inside the building, can only find its way in through some defect in the pipes or workmanship. The form illustrated [53] consists of a ball of wood, with a deep slot cut into it. Across the top of this a thin sealed tube of glass filled with prepared

chemicals is placed through two eyes, and held in position by an elastic band. The cord attached to the ball when the ferret is to be used is placed in the slot below the tube, and the ferret can be inserted under the seal, and will float on the drain side of the trap. A sharp jerk of the cord will snap the tube and scatter the contents in the water, upon which the fumes will be generated; if any defect exists in the pipes or fittings the smell will be detected.

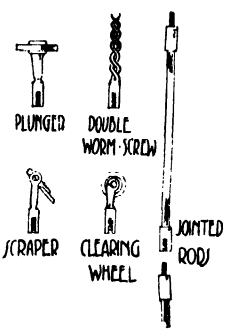
The Cleansing of Drains. Even self-cleansing drains are liable to some fouling, and should have occasional attention. In case of an actual stoppage of the drain, notice will probably be given by the overflow of one or more gullies. If the stoppage is in the intercepting trap, and the cleansing eye is accessible by means of a chain, as recommended, this should be at once removed. This will allow most of the water held up in the system to escape; the remainder must be bailed out, unless the stoppage can be removed otherwise. If a stoppage occurs at some intermediate point, cleaning rods are used [54]. They are long rods made up of short lengths, which can be screwed together to make any required length. The point of stoppage is located from the manhole above or below it. If the rods can be worked from the manhole above, the *plunger* is fixed to the end of the rod, and the obstruction is pushed down the pipe to the next manhole, and removed. If the upper manhole is inaccessible from being charged with sewage, the *double worm-screw* is fixed to the top of the rod, passed up from below, and screwed into the obstruction, which may then be withdrawn.



53. FERRET

The *scraper* may be used for clearing partial obstructions in the invert of a drain, and the *wheel* for exploring a drain to locate an obstruction. All traps having containers for gravel or similar material require periodical cleansing, or the trap itself may be blocked. All traps with gratings require to be cleared of leaves or other obstructions regularly, especially in the autumn.

It is desirable to flush out drains from time to time, but it is useless to do this from a small hose, which will never fully charge the pipe. If there is no flushing-tank, a large tub, holding 50 gallons or more, should be filled and emptied rapidly into the top manhole. This will fully charge the outlet and flush out the drain.



54. APPARATUS FOR CLEANSING DRAINS

Drainage of Complicated Buildings. It has been necessary in dealing with this subject to illustrate the work by plans of a not unusual though not very simple type, but it may happen that in the construction of a large building consisting, it may be, of several blocks more or less detached—for example, a thoroughly modern hospital on an open site—that the drainage of different parts must be dealt with as individual blocks, and that a main drain will take the place assigned to the sewer. But no new principle will be involved. Each block so dealt with will be treated as if it were an entirely separate and detached building with its own intercepting chamber and trap and system of ventilation. The main drain receiving the sewage from these branches will in turn be provided with an intercepting chamber and trap to cut it off from the public sewer, and will have its separate system of ventilation.

Level of Sewers. The most serious difficulty in dealing with the drainage of any given site occurs when the sewer into which the drainage is to be taken is at such a level that there is difficulty in securing an adequate fall. The level of the invert of any sewer at any given point, or at least at every road manhole, can, as a rule, be ascertained by applying to the surveyor or engineer of the authority controlling the public sewer. This should be done in all cases where a basement storey or storeys are intended to be introduced, or very great difficulties may result when the drainage comes to be dealt with. If this is done in good time, a little alteration in the floor levels may get over the difficulty. There are districts where the local authorities decline to connect any drain from a basement storey with the public sewer, on account of the occasional liability to flooding when the sewers are fully charged.

In cases of this kind, an iron system of drain pipes may sometimes be used with great advantage, for the system can be rendered so entirely watertight and airtight that the drains themselves may be exposed within the building and hang suspended from the ceiling of the basement storey, so that the lowest floor, and sometimes more than one floor, may be below the level it is possible to drain; but care must be taken not to provide any kind of fitting from which a drain would need to be taken below the drainage level.

Repairs of Drains. When a drain has once been laid and embedded in concrete, it is a troublesome and costly business to take it out and replace it. A drain so protected, especially if deeply laid, is not readily disturbed; but owing to the movement of the surrounding soil an earthenware drain may under some circumstances be cracked and cease to hold water. If the drain is so disturbed that a pipe is actually broken through and shifted, so that the two parts are no longer concentric, as a rule complete relaying is necessary; but, short of this, it is now possible by means of special apparatus to force liquid cement into the drain without disturbing it, and make good the defect at a greatly reduced cost. Such work, however, is in the hands of special companies, who possess patent rights over the necessary apparatus.

R. ELSEY SMITH

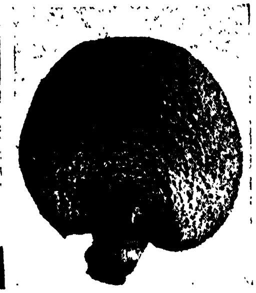
ERRATA—Page 359. Messrs. H. C. Szerelmey inform us that their stone liquid is not a soluble glass and contains no silica.

BRITISH MUSHROOMS AND TOADSTOOLS


Geaster fornicatus


Clavaria fragilis


Collybia fusipes


Polyporus squamosus


Stropharia æruginosa


Amanita spissa


Cantharellus cibarius


Lactarius piperatus


Amanitopsis vaginata


Laccaria laccata


Hyphallus impudicus


Cortinarius hinnuleus


Boletus versipellis


Clitocybe nebularis


Clavaria stricta

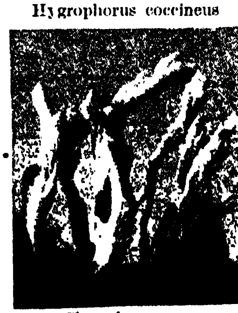

Polystictus versicolor


Hygrophorus coccineus


Clavaria inæqualis


Cantharellus tubæformis


Clavaria kunzei


Clavaria rugosa

178. INTERESTING FUNGI TO BE FOUND IN THE BRITISH ISLES

Seaweeds. Diatoms. Mushrooms and Toadstools. Fairy Rings. Moulds. Yeast and Lichens.

THE LOWEST PLANTS

The plants with which everyone is familiar mostly belong to the groups which have now been described, for these include the forms which make up the green covering of the earth. Seed-plants, in particular, compel our attention by reason of their size, the conspicuous flowers so many of them bear, and, not least, their economic importance.

The group of lowest plants, *Thallophytes*, however, embrace a larger number of species than all the others put together, and these are of such varied kind that some are to be found almost everywhere. The plant-body is technically known as a *thallus*—namely,an expansion which is not divided into root, leaf, and stem. The lower liverworts, as we have seen, are in much the same case. Thallophytes are conveniently divided into three great groups—Algæ, or Green Thallophytes; Fungi, or Colourless Thallophytes; and Lichens, which are of mixed nature.

Algæ. Though all green thallophytes, or algæ, possess the typical green colouring matter (chlorophyll), regarding which a good deal has elsewhere been said, this is in many cases obscured by the presence of brown or red pigment, which serves as a shield against excessive sunlight. We can therefore speak of "brown" and "red" algæ, as opposed to "green" algæ, in which the chlorophyll is obviously present.

The seaweeds which cover the rocks between tide-marks are the best known brown algæ, and attract the attention of every visitor to the seaside. The popular name for them is "wrack," and there are many common species round our coasts.

Bladder-Wrack. One of the most abundant is bladder-wrack (*Fucus vesiculosus*), the forking thallus of which is attached at one end, and when covered by the tide is buoyed up by numerous air-containing swellings. If a small piece of this or any other brown seaweed is placed in alcohol, the brown pigment will rapidly dissolve out, and a green hue will be assumed—*i.e.*, the chlorophyll will become visible. In winter and early spring the tips of wrack branches swell up and assume a yellow or orange tint. If such a swelling be held up to the light, a number of little round dots of darker tint will readily be perceived. Each of these is in reality a pit, or "conceptacle," lined by hairs, some of which are modified into egg-organs, sperm-organs, or both (according to the species). Figure **179** shows an enlarged view of a section through a female conceptacle, containing only egg-organs. Each of these is an ovoid body on a very short stalk, and containing eight egg-cells. The sperm-organs are minute bladder-like structures borne on branched hairs, and giving rise to large numbers of excessively minute sperms. When a ripe egg-cell is liberated, numerous sperms are attracted to it, and one actually fuses with it, thus bringing about fertilisation.

Weather-Glasses. Beginning near low-water mark and extending some distance into shallow water we find the "Laminaria zone," so called after brown seaweeds of that name. They are larger and broader than the wracks, and the thallus is smooth or corrugated, according to the species. It is these plants which are so often taken home by seaside visitors to serve as "weather-glasses," as, owing to the salt which clings to them, they become damp on the approach of rain.

Brown Seaweeds of Deeper Water. Large masses of seaweed are to be found drifting about in the ocean, especially in the Sargasso Sea, a huge eddy occupying several thousand square miles of the North Atlantic. The most notable form here to be seen is the "gulfweed" (*Sargassum bacciferum*), which is buoyed up by stalked floats resembling berries in appearance. A huge brown seaweed (*Macrocystis pyrifera*), with pear-shaped floats, native to the non-tropical parts of southern seas, attains the astonishing length of several hundred feet. Fucus and Laminaria are largely used as manure, and under the name of "kelp" were formerly employed in the manufacture of soda. As a source of iodine they are (especially Laminaria) still invaluable.

Diatoms. The almost infinitely varied microscopic forms known as diatoms, which possess flinty coverings of great beauty, may be reckoned as the humblest of the brown seaweeds. They are to be found in both salt and fresh water, and even on the surface of damp earth. Large tracts of the ocean floor, especially in the Antarctic regions, are covered with fine "ooze" principally composed of their remains. Some diatoms are stalked and immobile, but the larger number are free, and, like many of the lowest plants, possess the power of movement. When examined under a microscope they may be seen gliding along in a very interesting and curious fashion [**180**].

The surface layers of the sea and of lakes are inhabited by countless myriads of diatoms, which constitute the chief food of innumerable minute animals, especially the lowly cousins of shrimps and prawns. These little creatures in their turn are devoured by herrings and many other sorts of fish, so that man himself is indirectly indebted to diatoms for an important part of his diet. And this becomes still more obvious when we remember that oysters, cockles, and mussels feed upon these lowly plants wholesale.

Red Seaweeds. Most red seaweeds [183] inhabit moderate depths in the sea, and are unsurpassed for their beauty of form and colour. Many of them are torn from their moorings and cast up on the shore by storms. The reproductive processes are too complex to be discussed here. Some of the red seaweeds are strengthened by calcareous matter, and these "nullipores" are represented on our own coasts by branching forms and pinkish crusts which are to be found on rocks between the tide-marks. "Carrageen moss" (*Chondrus crispus*) is a stoutly built, forking red seaweed which grows on the coast of Britain, and has been used in much the same way as isinglass. "Laver" is another edible species, with a fairly broad, branching thallus. It is exposed for sale in Scotland, and in South Wales is mixed up with dough and baked into a sort of bread.

179. THE MALE FRUITING AREA AND THE FEMALE CONCEPTACLE OF THE BLADDER-WRACK
In the left-hand photograph the spermatozoids are seen in their receptacle, and in the right are seen the dark egg-cells fertilised by the spermatozoids. These microphotographs and others on these pages are by Mr. J. J. Ward.

Green Algæ. While red algæ are almost exclusively marine, the green ones abound both in salt and fresh water. None of them are of great size, and large numbers are microscopic [181–2]. Some of the larger forms are to be seen between tide-marks, such as "sea lettuce" (*Ulva*), in which the flat thallus is of a brilliant green, and *Enteromorpha*, made up of tufted hollow threads. The group may perhaps be best illustrated by taking two or three typical species.

Chara. Chara is a somewhat anomalous green alga, which is often to be found growing in dense masses in the ponds of chalk districts. It consists of a slender axis bearing circlets of branches, and suggesting in appearance a horse-tail, though on a much smaller scale. The lower end is fixed in the mud by means of long, fine root-hairs. Upon the branches are groups of slender projections, which are possibly to be regarded as incipient leaves. The axis and its branches are covered by cells arranged in a spiral manner, and the whole plant is encrusted with carbonate of lime.

Towards the end of summer egg-organs and sperm-organs are developed in pairs on the branches, in association with the "leaves." The egg-organ is brown in colour and of ovoid shape, with a spiral covering, and a "crown" of pointed cells. It contains a single egg-cell, to which a passage leads down between the crown-cells at the time of maturity. The orange-coloured sperm-organ is a hollow sphere, the wall of which is made up of eight triangular plates, elegantly fluted. From each plate a sort of "handle" projects inward, and this bears several long threads, composed of a large number of cells joined end to end. Within each of these cells a spirally shaped sperm is produced, one end of which is provided with two long, whip-like threads of living matter (protoplasm), the lashing movements of which propel it through the water. The ripe sperm-organ falls to pieces, and the innumerable sperms developed within it swim away. Fertilisation is effected as usual, by the fusion of the sperm with the egg-cell. The fertilised egg-cell, surrounded by its spiral investment, falls to the bottom of the pond, and remains dormant during the winter, germinating in the following spring into a new plant. Chara, and a related form (*Nitella*) which differs from it in certain details, have long been employed to demonstrate the movement of living protoplasm within vegetable cells. [See LIFE AND MIND.]

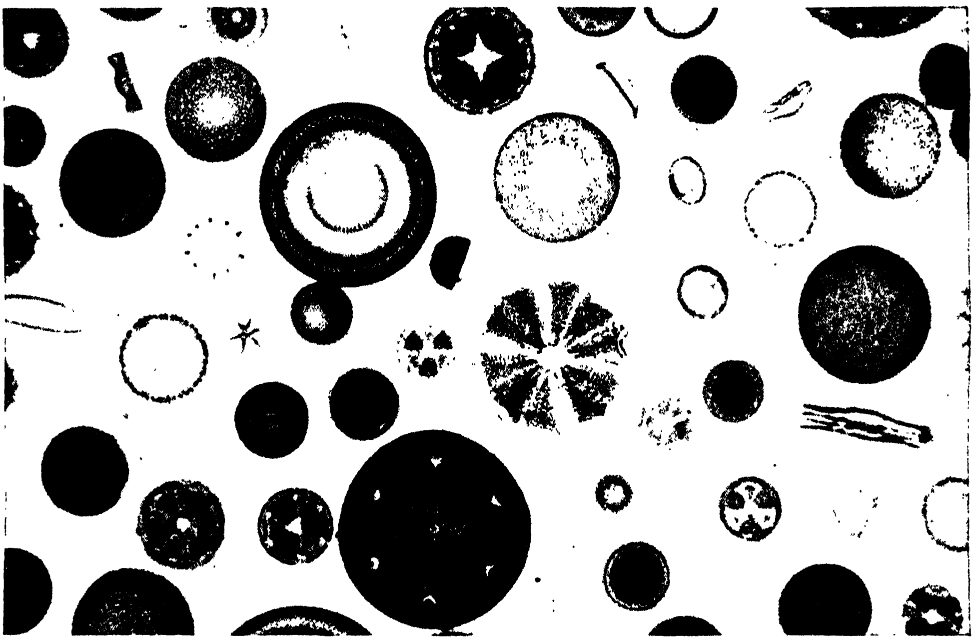
Spirogyra. Many thread-like green algæ live in ditches and ponds, some attached by one end, and others simply floating. One of the commonest of the latter is spirogyra, which is simply a row of hollow, cylindrical cells, bounded by delicate elastic cell-walls. Each cell is lined by protoplasm, and the nucleus is suspended by

delicate strands of the same substance in the central sap-filled space. A spiral band of the external protoplasm is impregnated with chlorophyll, and in it are to be seen a number of little, rounded bodies (*pyrenoids*) concerned with the manufacture of starch.

During spring and summer Spirogyra is constantly increasing in length by division of the constituent cells, and pieces are frequently separated to form new and distinct plants. But on the approach of autumn the process of "conjugation" takes place, which is comparable to egg-propagation, but is simpler, inasmuch as there is only a faint indication of a distinction between egg-cells and sperms. The adjacent cells of two contiguous filaments send out processes which meet, fuse together, and make a conjugating tube. Meanwhile, the protoplasm of each cell contracts into a rounded mass. One of these squeezes through the conjugating tube and fuses with the protoplasm of the other cell, to make a "resting-spore" [185]. This develops a firm covering, and remains dormant through the winter, growing into a new plant in the next spring. The filaments themselves break up and die.

Desmids. If, during spring or summer, some of the mud from the bottom of a pond is examined under the microscope, it will almost certainly be found to contain some of these elegant little plants, each of which consists of a single cell [184]. Many desmids are of extreme beauty, being only surpassed in this respect by diatoms, though, unlike these, they are not invested by flinty membranes. Some of them possess the power of movement. Desmids—and diatoms, also—conjugate in pairs to form resting-spores, which tide over the unfavourable winter season, in a similar manner to those of spirogyra.

Fungi. We have already had occasion to consider certain fungi which are associated with the roots of higher plants for mutual benefit, but this is a somewhat exceptional habit, as many of them (saprophytes) feed upon decaying vegetable or animal matter, while others (parasites) prey upon the living bodies of animals or other plants. Fungi are conveniently called "colourless" thallophytes to indicate the fact that they contain no chlorophyll, in the absence of which they are unable to use sunlight for the purpose of building up organic substance from water and carbon dioxide. They may, however, be of the most varied hues, including green. It would need a complete treatise to do justice to the wealth of forms included in the group, so we must content ourselves with considering a few of the commoner or more interesting types of fungi.



180. A MAGNIFIED GROUP OF THE BEAUTIFUL FLINTY COVERINGS OF DIATOMS

Mushrooms and Toadstools. The actual mushroom or toadstool plant consists of a mass of branching fibres, which ramify in the surface layers of the soil, and constitute what is technically known as the *mycelium*, or, in popular language, the "spawn." This gives rise to the stalked spore-producing structure which is seen above ground, and which is made up of closely interwoven and compacted threads. When fully developed, the under side of the expanded top of a mushroom or toadstool will be seen to possess a large number of radiating plates, or "gills," on the surface of which the dustlike spores are produced in immense numbers [178]. The gills vary in colour with the species, being, for instance, in the edible mushroom, pink, brown, or black, according to age.

181. UNICELLULAR ALGÆ, GLOEOCYSTIS

182. A FRESH-WATER ALGA, DRAPARNALDIA
Showing its threads of cells supported on specialised large cells

183. FROND TIP OF FEATHERY PTILOTA

A thin section through part of a gill, when examined under the microscope, will show that the surface layer is made up of closely packed, club-shaped cells, drawn out into pointed projections, the ends of which swell up into spores. These are so minute that they are readily dispersed by the wind, and germinate into new plants under favourable conditions. The fairy rings of our meadows are due to the gradual outward extension of an original clump of toadstools, the central patch being bare as a result of exhaustion of the soil.

Sponge Toadstools and Puff-Balls. The sponge toadstool (*Boletus edulis*) looks like a clumsily built brown-tipped mushroom. Instead of gills, however, we find a spongy mass made up of elongated tubes lined by spore-producing cells. A stalkless member of the same group (*Polyporus*) is often seen as a sort of semi-circular plate projecting from the trunk of a tree or a decaying gatepost. One species is used for preparing tinder. The "dry-rot" of timber is due to another toadstool which is a member of this group. Puff-balls are closely related to toadstools, but the spore-producing bodies are quite differently shaped, being rounded structures within which spores are developed, to be liberated at length by the bursting of the mature puff-ball.

Morels and Truffles. These differ from the preceding in that their spores are developed within tubular cells instead of projecting freely from the surface. The spore-producing body of the edible morel (*Helvella*) is club-shaped, the swollen part being yellow in colour, and its surface studded with projections.

Truffles live entirely underground, where their spore-producing bodies are developed as tuber-like thickenings. They possess a characteristic odour, and, as is well known, are hunted out with the aid of pigs or dogs.

The best-known edible forms are mushrooms (*Boletus edulis*), a large species of puff-ball (*Lycoperdon deliciosum*), morels and truffles, but many others are eaten. It unfortunately happens that numerous species are virulently poisonous; and as some of these closely resemble edible forms, it is wisest to refrain from making gastronomic experiments on the group, unless the advice of a specialist is available.

Moulds. It is a familiar fact that jam, cheese, bread, fruit, and many other articles of food, as well as leather and so forth, are liable to become "mouldy" if kept in a damp place. This is because they have been infected by the spores of the lowly fungi known as "moulds," of which a great variety are known to botanists.

Green Mould (*Penicillium glaucum*). This common form is often to be seen on oranges and bread, among many other things. The plant-body, or mycelium, is made up of excessively delicate branching threads, some of which grow into the air and assume the form of antique candelabra, the branches of which give rise to rows of spores that are disseminated by the least breath of air. A more complicated process of reproduction, involving fertilisation, has also been described. The blue mould

(*Aspergillus*) of cheese is broadly similar, but the spore-bearing branches end in swellings, from which numerous long chains of spores radiate.

White Mould. White mould (*Mucor*) is often to be seen on bread and horse-dung. The mycelium is made up of whitish, cobwebby fibres, from which long spore-bearing branches rise into the air. Each of these ends in a rounded swelling [186], within which numerous spores are produced. There is also a process of conjugation between specialised mycelial branches, by which resting-spores with firm investments are produced. These are able to remain dormant for some time, and thus enable the fungus to combat unfavourable surroundings.

All the fungi so far described are saprophytes, which live upon dead organic matter; but some of the moulds infest living plants, such as cereals, peas, and vines. Besides these there are many other parasitic forms, which are described in the chapter on "Plant Pests."

Yeast. If a little yeast is examined under a strong power of the microscope it will be found to contain innumerable ovoid yeast-plants, each consisting of a single cell and reproducing for the most part by a process of budding. Under favourable conditions a yeast-plant may become a spore-case, within which are developed four spores that are able to remain in a state of suspended animation for a long time, should the surroundings still be adverse. They are so minute that they can be blown by the wind for great distances, and some of them are likely to reach a spot where circumstances are in their favour.

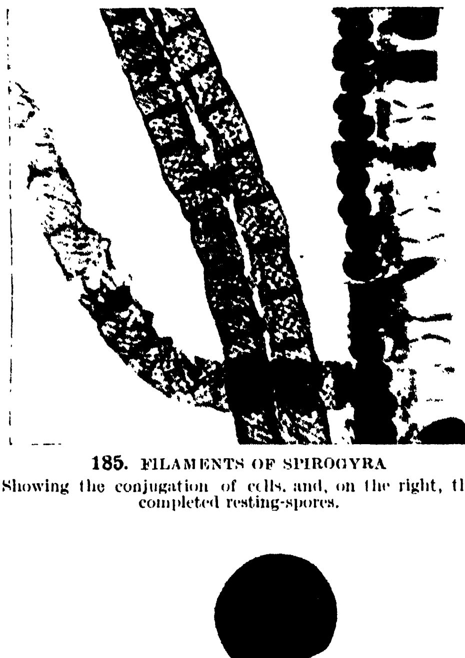
Alcoholic Fermentation. The most remarkable fact in regard to the vital processes of yeast is that when placed in a sugar-containing solution it is able to break up the sugar, with production of alcohol and carbon dioxide. This "alcoholic fermentation" is clearly of great economic importance. It is the production of gas by the yeast which is mixed with dough that causes the bread to "rise"—that is, to become of spongy texture instead of remaining dense and tough.

Lichens. The familiar plants known as lichens are found everywhere, in the form of variously coloured crusts on rocks and walls, tufted growths on the trunks of trees, and so forth. As already mentioned, a lichen is a joint-stock company, consisting of an alga associated with a fungus, both of which can clearly be seen in a thin section placed under the microscope. Spores developed in club-shaped cases are produced in special, cup-shaped outgrowths, or it may be thickened projections. The spore-cases are the result of growth subsequent to a process of fertilisation.

Two lichens are of particular economic interest. One of these is the so-called Iceland moss (*Cetraria Islandica*), which is used as a food in Iceland, and was formerly valued as a remedy for chest diseases. The other is reindeer "moss" (*Cladonia rangiferina*), of high latitudes, which during the winter forms the almost exclusive food of the reindeer.

J. R. AINSWORTH-DAVIS

184. DESMIDS—A HUNDREDTH OF AN INCH WIDE



185. FILAMENTS OF SPIROGYRA
Showing the conjugation of cells, and, on the right, the completed resting-spores.

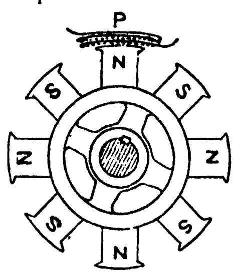
186. WHITE MOULD—MUCOR MUCEDO
Showing the spore-cases

Properties of Alternating Currents. Alternators. Armatures and Magnet-wheels. Questions of Lag and of Phase.

THE ALTERNATOR

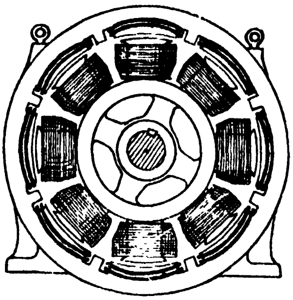
Alternating Currents. Electric currents supplied from a battery are described as *continuous* currents because they flow continuously in one direction around the circuit. But there is another kind of electric current, which has the property that, instead of flowing, in one direction along the conducting wire, it is continually flowing backward and forward in rapid alternations of directions. Such currents might be called oscillatory or undulatory; but the accepted name for them is *alternating currents.* They are much used for long-distance transmission work. A part of the City of London is supplied with electric energy from a generating-station at Bow, five miles away. The current is at one instant flowing between Bow and London; at the next instant it stops, and then reverses in its direction; then stops, and reverses again, and flows in the original direction, and so on in rapid succession, reversing actually 100 times a second. Two such reversals constitute one *cycle*, and the time occupied by one cycle is called one *period.* So that in this case there is a *frequency* of 50 cycles per second, or the *period* of the current is $\frac{1}{50}$ of a second. Frequencies of 100 cycles per second were formerly used for electric lighting, but a frequency of 50 is now preferred; while for special power-plant (as at Niagara) the lower frequency of 25 cycles per second is adopted.

Alternating Voltage. In order to cause the current to rush forwards and backwards 50 times a second it is clear that the electromotive force which is applied to generate the current must itself be alternating with the same frequency—in each second there must be 100 electromotive impulses, 50 of them tending to drive the current forward, and 50 of them tending to drive it back. How shall this be accomplished with so great a rapidity? How can the revolutions of a steam-engine set up such rapid alternations?



84. MAGNET-WHEEL, 8-POLE

Alternating Induction. On page 888, on the discoveries of Faraday, we described the inductive effect of plunging the pole of a magnet into a coil of wire. It was pointed out that when the pole is plunged in there is a current induced in the coil, and that when the pole is pulled out there is a reverse current induced in the coil. It is clear that if we could push in and pull out that pole 50 times a second we should generate alternating currents having a corresponding frequency. But it is not necessary that the magnet-pole should enter the coil. As pointed out in that chapter, all that is necessary is that there should be *relative movement* of the conducting copper wire and the magnet-pole, so that the magnetic lines of the pole shall be "cut" by the copper conductors. Consider, then, how we might design a machine to be driven by a steam-engine that would give us this rapid alternating induction of voltage. Suppose a number of electromagnets to be fixed upon the rim of a steel wheel, with their poles pointing outwards, as in **84**, and so arranged that these poles shall be alternately north poles and south poles. Then let a coil (P) of insulated wire be wound upon a suitable core (built up of iron plates) and fixed opposite one of the magnet-poles. (It is assumed that the electromagnets fixed on the wheel can be kept magnetised, as described hereafter.) Then, if the magnet-wheel is revolved, as its poles fly past the fixed coil there will be induced in the coil a succession of electromotive impulses that tend to set up alternating currents. For while a north pole is coming up, the induction will act one way round the coil, and while the north pole is retreating and a south pole is coming up, the induction will act the other way round the circuit.



85. ALTERNATOR, 8-POLE

Frequency and Number of Poles. Fig. **84** represents the magnet-wheel as having eight poles—that is, four norths and four souths. In one revolution it will, therefore, induce eight alternations or four complete cycles. If a frequency of 50 cycles per second is wanted, the wheel must be driven at a speed of 12½ revolutions per second or 750 revolutions per minute. If the wheel had had only four poles it would have needed to be driven at 1,500 revolutions per minute to give the standard frequency of 50 cycles per second. If we were compelled to use a slow-speed steam-engine making only 150 revolutions per minute, the magnet-wheel would require 40 poles. The table on the next page shows the relation.

Engine-speeds for a Frequency of 50 Cycles per Second

No. of Poles.	Cycles per Rev.	Revs. per Sec.	Revs. per Min.
2	1	50	3000
4	2	25	1500
6	3	$16\frac{2}{3}$	1000
8	4	$12\frac{1}{2}$	750
10	5	10	600
12	6	$8\frac{1}{3}$	500
20	10	5	300
30	15	$3\frac{1}{3}$	200
40	20	$2\frac{1}{2}$	150
60	30	$1\frac{2}{3}$	100

Such high speeds as 1000 revolutions per minute or more are suitable only for steam-turbine driving. The frequency (f) can be calculated from the revolutions per minute by dividing the latter by 60 and then multiplying by the number of *pairs* of poles. Thus, a 10-pole machine running at 720 revolutions per minute will give a frequency of 60 cycles per second.

Armatures for Alternating Generators. When it is desired to generate high voltages, not only must the magnet-poles be such as to furnish an adequate flux of magnetic lines, but there must be a sufficiently large number of turns of copper wire in the coils that are to be acted on inductively by the revolving poles. In **84** only one coil is shown. But if, as in **85**, there are provided as many coils as there are poles, and if the coils are so spaced out that at the instant when one of them is opposite a pole all the others are also opposite the respective poles, then they will all work together, and may be connected up into series as one winding. Such a group of connected coils, together with the laminated iron cores on which they are wound, and the frames in which they are held, will be called the *armature* of the machine. As it usually stands still, such an armature is also called a *stator*. The coils must be so joined up that the currents circulate.

Alternators. The entire machine, consisting of field-magnet and armature, is called an *alternating current generator*, or *alternator*. We have seen that it may be regarded as evolved from Faraday's original apparatus. It is made in many sizes, from the little *magneto ringers* used in telephone work for ringing the calling-up bells, to huge generators 20 or 30 feet in diameter, requiring several thousands of horse-power to drive them.

It is easy to calculate out from the constructive data of a machine, and the speed at which it is driven, the voltage at which it works; for the voltage it generates is proportional to its speed, to the number of its poles, to the number of coils in series on its armature, and to the flux of magnetism in any of its poles. The formula by which to calculate the voltage is

$$E = k \times f \times Z \times N \div 10^8$$

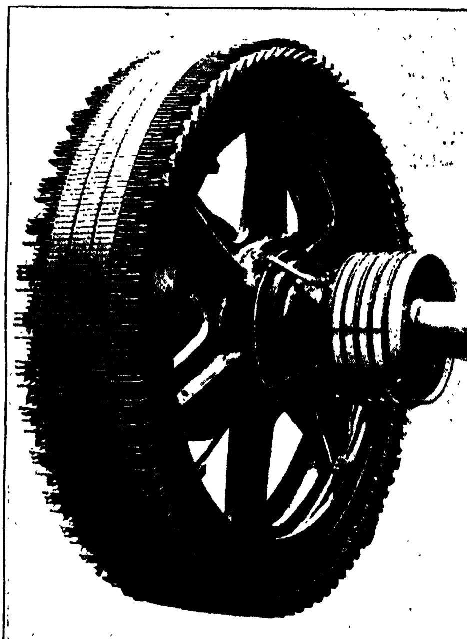
where N is the number of lines in the flux from any one pole, Z the number of conductors or turns in series with one another in any circuit of the armature, f the frequency, k a coefficient depending on the shape of poles and distribution of the windings (k is usually of the value 2·2), E the voltage of the alternator, and 10^8 is the numerical factor to reduce to volts, because, as explained on page 1152, to create one volt there must be 100,000,000 magnetic lines cut per second.

As an example, suppose this 8-pole alternator [**85**] to run at 750 revolutions per minute, and to have 36 turns on each of the eight armature coils, and $3\frac{1}{2}$ millions of lines as its pole-flux. As each of the eight coils has 36 turns, Z will equal 576. If it run at 750 revolutions per minute, this is $12\frac{1}{2}$ revolutions per second, and with four pairs of poles in the circumference the frequency will obviously be 50 cycles per second. Then, taking $k = 2·2$, we have:

$$E = 2·2 \times 50 \times 576 \times 3{,}500{,}000 \div 100{,}000{,}000,$$

or, working the arithmetic,

$$E = 2217·6 \text{ volts.}$$



86. TWO-PHASE "A" TYPE 30-POLE ARMATURE

Types of Alternators. There are three leading types of alternators — namely, (A) small machines, having stationary field-magnets, resembling the field-magnets of multipolar dynamos, and with revolving armatures; (B) large machines, with revolving magnet-wheels (as in **85**) and stationary armatures; (C) high-speed machines, for steam-turbine driving, having external stationary armatures and internally revolving field-magnet systems of peculiar construction. There is yet another type, not much seen now, in which the armature stands still, and the magnetising coils of the field-magnet also stand still, the only thing that revolves being masses of iron fastened to a shaft, and which, when they are magnetised, act inductively. These are called *inductor alternators*. Alternators of the A type, with revolving

armatures, require sliding contacts to connect the revolving coils to the external circuit. These sliding contacts are made by connecting the ends of the armature winding to insulated metal rings, known as *slip-rings*, fixed on the shaft. Against these metal rings press collecting brushes of metal or carbon. Any single-circuit alternator of this type will require two such slip-rings. But there are machines with three circuits, called three-phase alternators, which require three slip-rings, and two-phase alternators with four slip-rings, as **86**. Owing to the difficulty of satisfactory insulation of revolving windings, if high voltages are required it is much preferable to employ machines of the B type, with stationary armatures.

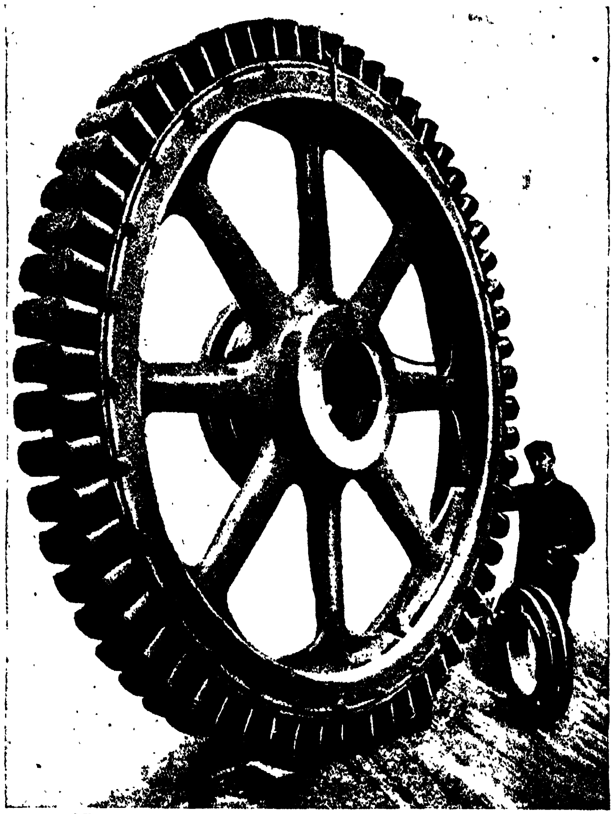
Revolving Magnet-wheels. As we have seen, these structures present a set of radiating poles. The pole-cores are sometimes of solid steel, sometimes built up of steel stampings, but, in any case, they must be stoutly secured by dovetails or by bolts to the rim of the foundation wheel; and this is often made of immense thickness to serve also as a fly-wheel.

Fig. **87** shows such a magnet-wheel separately. To magnetise the poles, the projecting iron cores are wound with massive coils, usually composed of copper strip about one inch broad and one-tenth inch thick, wound edge-wise. The magnetising current must be brought from a continuous current machine, called an *exciter*; and, as it must be brought to the revolving structure, sliding contacts are necessary, two slip-rings being fixed on the shaft to receive the exciting current from the contact-brushes and to convey it to the magnetising windings. These slip-rings are seen illustrated in **87** ready to be fixed upon the shaft.

A smaller magnet-wheel with eight poles is shown in **88**; in this case the slip-rings are attached, and their connection to the exciting coils on the poles is clearly shown.

Stationary Armatures. The *core-body* of a large slow-speed alternator is a great ring built up of thin stampings of soft steel or iron, fixed in a strong cast-iron *housing*. The coils, previously shaped on wooden formers, are inserted in slots in the peripheral face of the core, and are fixed in with wooden wedges. When the magnet-wheel is in its place, and revolving, the magnetic fluxes from its poles sweep past these coils and induce electromotive forces in them. One of the largest of these machines is of 8000-horse power, running at 75 revolutions per minute, in the Manhattan station at New York. It is about 30 feet in diameter. But smaller machines of greater power for driving with steam turbines at high speeds have been built.

The Parsons Company have just completed for the Commonwealth Electrical Company of Chicago a turbo-alternator, which is not only one of the largest but promises to be the most economical machine of the type yet constructed. It not only exhibits the advance made in the efficiency of electric generators, but also shows that this country is still in the forefront in this branch of engineering. The turbo-generator is of 25,000 KW output when working at 750 revolutions per minute, the frequency of the three-phase current being 25 periods per second, and the voltage 4500 volts. The guaranteed



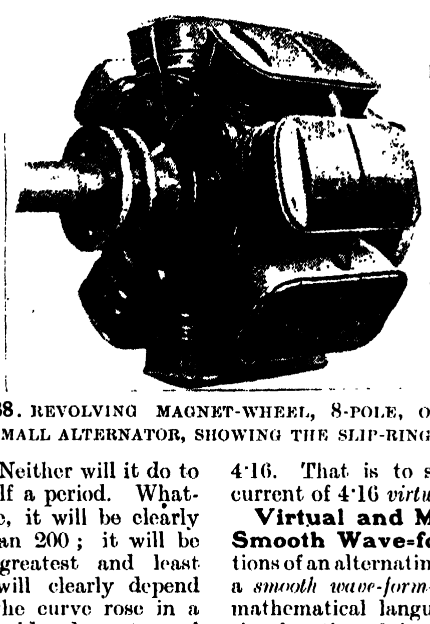
87. SIXTY-POLE MAGNET-WHEEL OF ALTERNATOR

steam consumption at normal load is $11\frac{1}{4}$ lb. per kilowatt-hour, with steam at 200 lb. pressure superheated to the extent of 200° Fahr. This is equivalent to a consumption of 8·15 lb. of steam per h.p. delivered—a record, even for marine practice. Some idea of the size of the generator may be gained from **93**.

Wave-form of Alternating Impulses. Consider, in detail, how an alternating electromotive force, or an alternating current, varies within one cycle. The impulse begins, it increases in strength up to a maximum, then it dies away to zero, reverses, increases, in the opposite direction, to a negative maximum, and finally dies away to zero, to begin a new cycle. If we divide the period of one cycle into quarters, we see that if the operation is symmetrical the two maxima—positive and negative—will occur at

the end of the first and third quarters. To represent such variation in detail, it is usual to depict them graphically in a wave-diagram, such as **89** (*a*), in which the horizontal measurement from left to right represents an ever-increasing time, and the vertical height above or below the level line represents the particular value of the impulse from instant to instant.

Fig. **89** (*a*) represents the impulse as going rather suddenly to its maxima, which are in the form of peaks. The shape of the curve which represents the periodic variations in the induced voltage is called *the wave-form* of the alternator. If the coils of the armature have a span equal to the pole-pitch, and are concentrated in narrow slots in a core of smooth periphery, the wave-form of the alternator will depend only on the shape of the magnet-poles. If these are pointed, the wave-form will be peaky; if they are broad and blunt [**89** (*b*)] the wave-form will be rounded, or rounded with flat tops. Narrow poles generally cause peaky waves. Wide slots in the periphery of the armature core cause distortions that show themselves as ripples on the outline of the wave-form. Thus **89** (*c*) is the wave-form of the alternating voltage supplied to the town of Carlsruhe.



88. REVOLVING MAGNET-WHEEL, 8-POLE, OF SMALL ALTERNATOR, SHOWING THE SLIP-RINGS

Virtual Value of an Alternating Voltage. Suppose an alternating voltage to vary during the period from 0 up to + 200 volts, then back to 0, then to − 200 volts finally back to 0, what will be its working value as a voltage? It will not do to take the mean or average in the ordinary sense, for the average taken from the beginning to the end of the period is clearly zero. Neither will it do to take the average during half a period. Whatever value is the right one, it will be clearly more than 0, and less than 200; it will be something between the greatest and least values. And the value will clearly depend on the question whether the curve rose in a peaky way, or in a round-shouldered way toward its maximum. A clue to the correct answer to the question may be found by inquiring how the instruments used as voltmeters and amperemeters for an alternating supply are constructed. If they are examined, it will be found that they indicate a special kind of mean of their own, which is neither an arithmetical nor a geometrical mean, but is a *quadratic mean;* or, in other words, they indicate the square root of the mean of the squares of all the values. It is impossible in the short space available to go fully into this. But, for example, it may be summarily pointed out that in those amperemeters and voltmeters which work on the principle of the expansion of a hot wire, the heat at every instant imparted to the wire is proportional to the square of the current in the wire; that the inertia, thermal and mechanical, of the instrument averages these squares; and that the dial is so constructed as to read in proportion to the square roots of the mean expansion. It may be remarked that in an alternating hot-wire amperemeter the point on the scale marked "10 amperes" *must* be that point to which the pointer goes when the wire is heated by 10 actual amperes going through it. And if an alternating current is sent through it of such a strength that it also sends the pointer to the same spot—that is, heats the wire to the same extent—such a current is virtually 10 amperes, and ought to be called so, though it will be varying between 0 and 14 amperes or so one way or the other. The value which instruments read is therefore called the *virtual* value; the adjective *virtual* (French *efficace*) meaning the "quadratic mean."

A numerical example will make things plainer. Suppose that a current varies between maxima of 6 and − 6 amperes. What is its virtual value? If **90** represent its wave-form, and if we divide the period into 12 equal parts, we shall find that we may represent the successive values in one cycle as follows:

$$0 + 3 + 5 + 6 + 5 + 3 + 0 - 3 - 5 - 6 - 5 - 3 - 0.$$

Now write down the squares of these numbers:

$$0 + 9 + 25 + 36 + 25 + 9 + 0 + 9 + 25 + 36 + 25 + 9 + 0.$$

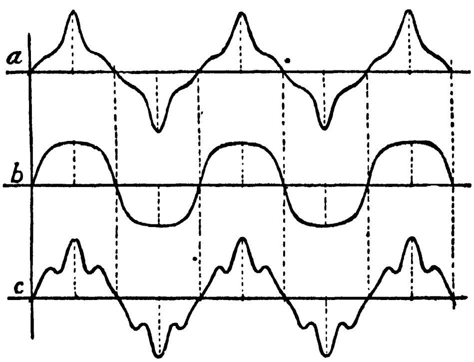
The sum of these squares is 208, and dividing by 12 gives us as the mean 17·33. Take the square root of 17·33 and we get as the quadratic mean, or virtual value, 4·16. That is to say, this is an alternating current of 4·16 *virtual amperes.*

Virtual and Maximum Values for a Smooth Wave-form. Suppose the variations of an alternating voltage or current to follow a *smooth wave-form*—and by this we mean, in mathematical language, that they vary as a sine-function of the time—then the virtual value will be 70·7 per cent. of the maximum, or the maximum will be 141·4 per cent. of the mean. Thus, if a voltmeter *reads* 100 virtual volts, we shall know that the voltage is actually varying between + 141·4 and − 141·4 volts. Or if it read 30 volts, we shall know that the value is really varying between + 42·42 and − 42·42 volts. If the wave-form be not smooth, the maxima will have some other ratio to the virtual value.

Closely connected with this point is the value of the coefficient k that comes in in the design of alternators. If the alternator is so designed that it gives a smooth wave-form, the value of k will be 2·22. If it is designed to give a more sloping curve, the value of k will be less, or if a

more high-shouldered curve; the value of *k* will be greater.

Lag and Lead. Every electric current is an effect of which the voltage applied to the circuit is the cause. If the voltage is an alternating one, it follows that the resulting current will be an alternating current and that it will have the same frequency as the voltage which causes it. But there is this difference: that the resulting alternating current may not follow the alternating voltage in all its details, nor does it always keep in exact step with it. The



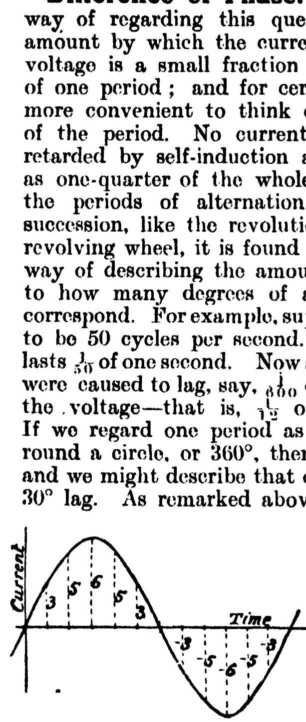
89 WAVE-FORMS OF ALTERNATING VOLTAGES

wave-form of the current may differ from that of the voltage, being modified by reactions due to apparatus in the circuit. This point need not trouble us. But of immense importance is the circumstance that the current will not necessarily keep step with the voltage. For it happens in almost every actual circuit in which alternating currents are used that the current *lags* a little with respect to the voltage. Let us understand what this means and why it occurs.

Fig. **91** depicts two alternating curves, marked V and C. If we look at the length on the time-line we see that the duration of the period of the C curve is the same as that of the V curve; but they do not begin together, they do not reach their top values together, they do not both die down to zero at the same instant. In fact, the C curve *lags a little* behind the V curve; and the amount that the C curve is shifted to the right with respect to the V curve marks the amount, in time, that one lags behind the other. This is a typical illustration of the way that the current C habitually lags behind the voltage V. The circumstance under which such a lag of the current occurs is whenever the circuit contains any coils that will magnetise. If any electromagnet, or any coil wound round an iron core, is inserted in the circuit, then the current on its way round the circuit must necessarily do some magnetising. While the current rises, the magnetism must grow; while the current is dying away, the magnetism must die. This growth and dying of the magnetism in the circuit itself set up self-inductive reactions, with the result that the current cannot grow up as quickly or as soon as it otherwise would do, and cannot decrease or die away as quickly or as soon as it otherwise would die. So it is compelled to lag. In other words, the lag of current is due to the self-induction in the magnetising coils in the circuit; and the self-induction not only causes the current to lag in time, but it is actually choked in amount: it cannot rise to so high a maximum as it otherwise would attain to if it were governed by the mere resistance of the circuit.

As a matter of fact, there is another case where the current is forced to occur earlier—that is, to *lead* instead of to *lag*. This occurs when a condenser, or anything else having electrostatic capacity, is introduced into the circuit; but this is not the place to enter on this question.

Difference of Phase. There is another way of regarding this question of lag. The amount by which the current lags behind the voltage is a small fraction of the whole time of one period; and for certain purposes it is more convenient to think of it as a fraction of the period. No current can be so much retarded by self-induction as to lag as much as one-quarter of the whole period. Now, as the periods of alternation recur in regular succession, like the revolutions of a uniformly revolving wheel, it is found to be a convenient way of describing the amount of a lag to say to how many degrees of an angle it would correspond. For example, suppose the frequency to be 50 cycles per second. Then one period lasts $\frac{1}{50}$ of one second. Now suppose the current were caused to lag, say, $\frac{1}{600}$ of a second behind the voltage—that is, $\frac{1}{12}$ of a whole period. If we regard one period as a revolution once round a circle, or 360°, then $\frac{1}{12}$ of this is 30°, and we might describe that current as having a 30° lag. As remarked above, the current can never lag more than 90°, that is $\frac{1}{4}$ period, behind its voltage.



90. WAVE-FORM OF ALTERNATING CURRENT

Now, this method of employing the language of angular measurement to describe a lag is convenient for another purpose—namely, to describe any difference of phase that there may be between two alternating currents. Suppose an alternator, such as **84**, to be constructed with two independent coils, marked P and Q in **92**, each wound in a pair of slots in the armature core; but let the slots be displaced, so that coil Q is fixed a little further to the right than coil P. Clearly, as the magnet-wheel revolves, it will set up two alternating voltages in these two coils, and if the coils have the same number of turns they will be equal, and certainly of the same frequency. But the voltage in Q will occur a little later than that in P, simply because Q is a little further on. So here we shall have the generation of two equal alternating voltages having a difference of phase between them. And this phase difference can be expressed also as an angle. For if Q is displaced from P by

an amount equal, say, to one-third of the pitch from one north pole to the next north pole, as measured round the periphery of the armature face, then the Q voltage will lag one-third of a whole period behind the P voltage, or there will be a difference of phase of 120° between the P voltage and the Q voltage.

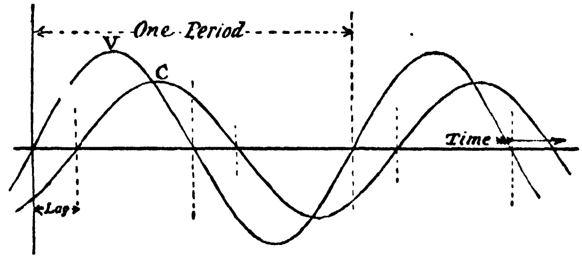
Two-phase. If, as in **92**, the Q coils are displaced exactly one-half of the pole-pitch from the P coils, then the difference of phase between the P voltage and the Q voltage will be one-quarter of a period. Any alternator wound with two independent sets of coils in two phases that are thus one-quarter of a period apart, is called in Europe a *two-phase* machine.

Three-phase. It may be remarked here that one might build an alternator with several different sets of coils, say, a P set, a Q set, and an R set, each displaced beyond the other so as to give rise to three separate voltages that differed successively in phase from one another. The well-known *three-phase* system of currents is nothing more or less than a system of three separate alternating currents which are in this way made to differ from one another in phase by successive angles of 120°. This system is dealt with in a later chapter, the present one not going beyond single-phase working.

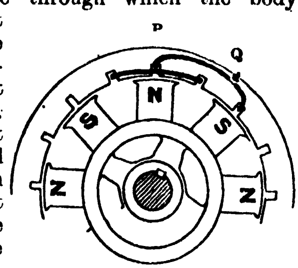
Power-factor. Returning to the lag of a current behind its own voltage, we come to a point of vital importance in connection with the *power* of alternators. When a current lags and gets out of phase with its own voltage, then just so far as it gets out of phase it ceases to be effective. For the power [see p. 234] which it conveys is the product of the volts and the amperes only so far as they act together. We come here upon a strict analogy with a most important principle in mechanics—namely, that the work done by a force in producing a movement—usually stated as the simple product (in foot-pounds) of the force into the distance through which the body has moved—is not true unless the force and the resulting movement are in the same line. If the movement is constrained and takes place in some direction at an angle with the force, then the work done is no longer the product of the feet and the pounds; it will be less than that product. The true amount of work can be calculated, as every student of dynamics knows, by multiplying the apparent number of foot-pounds by the *cosine of the angle* [see TRIGONOMETRY, in MATHEMATICS] between the direction of the force and the line of movement. Those who are unfamiliar with trigonometrical terms will find the following simple table useful:

Angle	Cosine of Angle	Power-factor, in Percentages	Sine of Angle	Idle Current, in Percentages
0°	1	100	0	0
5°	0·9962	99·62	0·0872	8·72
10°	0·9848	98·48	0·1737	17·37
15°	0·9659	96·59	0·2588	25·88
20°	0·9397	93·97	0·3420	34·20
25°	0·9063	90·63	0·4226	42·26
30°	0·8660	86·60	0·5000	50·00
35°	0·8190	81·90	0·5736	57·36
40°	0·7660	76·60	0·6428	64·28
45°	0·7071	70·71	0·7071	70·71
50°	0·6428	64·28	0·7660	76·60
55°	0·5736	57·36	0·8190	81·90
60°	0·5000	50·00	0·8660	86·60
65°	0·4226	42·26	0·9063	90·63
70°	0·3420	34·20	0·9397	93·97
75°	0·2588	25·88	0·9659	96·59
80°	0·1737	17·37	0·9848	98·48
85°	0·0872	8·72	0·9962	99·62
90°	0·000	0·00	1·000	100

Thus, if a force equal to the weight of 50 pounds, acting obliquely at an angle of 40° with the line of movement, produces a movement of 6 feet, the number of foot-pounds of work done will not be 300, because only a component of the force is in the line of movement. The true amount is found by multiplying the 300 by the cosine of 40°, namely, 0·766, making the true amount of work done 300 × 0·766 = 229·8 foot-pounds.



91. LAG BETWEEN VOLTAGE AND CURRENT



92. ALTERNATOR COILS IN TWO PHASES

In the same way, if a current is out of phase with its voltage, the true power in *watts* [see p. 234] will be less than the number of *volt-amperes* of apparent power; and the true *watts* can be calculated by multiplying the *volt-amperes* by the cosine of the angle of lag.

Thus, for example, let a current of 20 (virtual) amperes be sent round a circuit by an electromotive force of 100 (virtual) volts, and suppose that the current lags by 30°, then the apparent power is 2,000 volt-amperes. But since the cosine of 30° is 0·866, the true power is only 1,732 watts.

We may put this into a rule as follows:

True power = volts × amperes × power-factor.

It is for this reason that the cosine of the angle of lag is usually termed the *power-factor*. The usual lags occurring in practice are: For incandescent lighting, 16° to 20°; mixed arc and incandescent lighting, 30°; induction motors, large, 35°; induction motors, small and not

well loaded, 55° to 60°; choking coils, 95°; synchronous converters, 0° to 10°.

Idle Component. So far as the current is out of phase with its voltage, so far it is unable to be productive of useful work or to convey power. To understand this we may again resort to the analogy afforded by the similar case in dynamics. It is a well-known principle that a force does no work, spends no energy, if it acts at right angles to the line of movement. No power or energy is required to deflect a bullet from its path, provided the deflecting force acts always at right angles to that path. The earth exercises an attractive force on the moon to keep it in its orbit, but expends no power or energy on doing so, because the direction of the force is in quadrature with the direction of the motion. An oblique force can always be regarded as resolvable into two components, one in line with the motion (this is the working component), the other at right angles to the motion (this is an idle component).

Wattless Current. So with the alternating current. We may consider it, in fact, as if resolved into two components, one component in phase with the voltage, the other component at right angles (in the sense of 90° of lag) to the voltage. The former is the working component of the current, being the component that possesses the power, and proportional to the cosine of the angle of lag. The latter is the idle component, or wattless component of the current, which conveys no energy, because of its being in quadrature with the voltage. It is proportional to the sine of the angle of lag. The two last columns of the table give the corresponding values. If we take as illustration the same case as before of a current of 20 amperes lagging 30° in phase behind its voltage, we see, by reference to the table, that the sine of 30° is 0·5, and therefore that there will be 50 per cent. of idle current; that is, though the current is 20 amperes it acts as though 10 amperes were idle or wattless. In fact, the two components into which the current is split up are proportional, one to the sine, the other to the cosine of the angle; the working component is $20 \times 0{\cdot}866 = 17{\cdot}32$ amperes; the idle component is $20 \times 0{\cdot}5 = 10$ amperes. If we square each component, add the squares and take the square root, we obtain the value of the whole current: $(10)^2 = 100$; $(17{\cdot}32)^2 = 300$; $100 \times 300 = 400$; and $\sqrt{400} = 20$, as before. Any purely magnetising current is an idle one, having a power-factor practically zero.

Mean Power of Alternating Current. As the power at any instant is the product of volts and amperes at that instant, we can find the mean power by averaging a set of the instantaneous products. For example, let the current during one cycle have the values:

0 + 3 +5 +6 +5 +3 0 − 3 − 5 − 6 − 5 − 3 0

We have seen above that the virtual value of this current will be 4·16 amperes. Now suppose the voltage to vary between maxima of + 20 and − 20 volts in the following cycle, the virtual value being 14·1:

0 +10 +17 +20 +17 +10 0 − 10 − 17 − 20 − 17 − 10 0

Write them down one below the other, and put the products at each instant underneath, thus:

C	0	+ 3	+ 5	+ 6	+ 5	+ 3	0	− 3	− 5	− 6	− 5	− 3	0
V	0	+10	+17	+ 20	+17	+10	0	− 10	− 17	− 20	− 17	− 10	0
C × V	0	+30	+85	+120	+85	+30	0	+30	+85	+120	+85	+30	0

Adding up the products, we get 700, and dividing by 12 to take the average, we find the mean product to be 58⅓ watts. This practically agrees with the volt-amperes; for $4{\cdot}16 \times 14{\cdot}1 = 58{\cdot}6$.

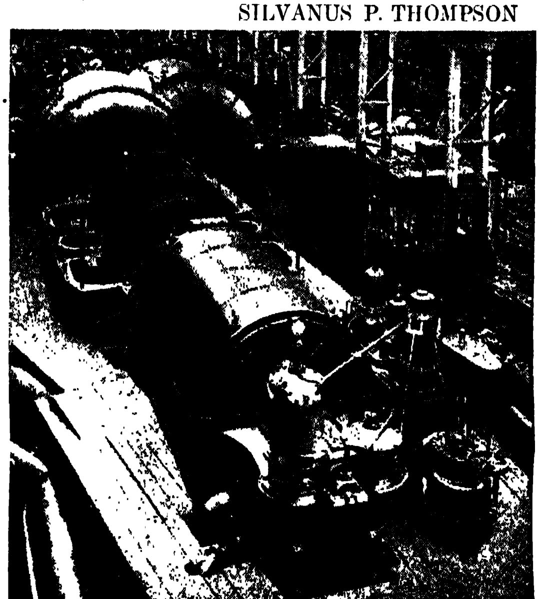
Now, if we suppose a lag of the current to take place, we must shift the numbers on accordingly. Suppose there is a lag of 30°. This means that the current figures must all be shifted on by one-twelfth of a cycle—that is, one place out of the twelve, thus:

C	− 3	0	+ 3	+ 5	+ 6	+ 5	+ 3	0	− 3	− 5	− 6	− 5	− 3
V	0	10	+ 17	+ 20	+ 17	+ 10	0	− 10	− 17	− 20	− 17	− 10	0
C × V	0	0	+ 51	+ 100	+ 102	+ 50	0	0	+ 51	+ 100	+ 102	+ 50	0

Adding up and dividing by 12 as before, we now find the mean power to be only 51 watts. But this agrees with what was said above; for to find the *true* watts we must multiply the volt-amperes by the power-factor, which is the cosine of the angle of lag. Now, the cosine of $30° = 0{\cdot}866$. And $4{\cdot}16 \times 14{\cdot}1 \times 0{\cdot}866 = 50{\cdot}8$, which gives practically the same result as that deduced by the process of averaging.

Anyone who doubts that, when the lag is 90° there is *no power*, should verify it by shifting the current figures till the maximum comes opposite the zero of the volt series, and then, having formed the products in the manner indicated above, taking the mean. The matter will then be clear.

SILVANUS P. THOMPSON



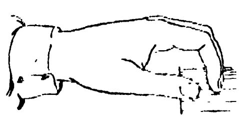
93. THE PARSONS' TURBO-ALTERNATOR OF 25,000 K.W. OUTPUT, AS ERECTED IN CHICAGO.

Position of the Hands. How to Depress the Keys. Exercises. Sustained Tones. Resting. Tone Quality.

HOW TO PRODUCE SOUND

We shall try now to rest the hand on the keys in the *position* of 5 [page 1156], but in the *condition* suggested by 4, remembering always that the condition is the essential thing. To get this we must try carrying the loosely hanging hand to the keyboard by a movement of the arm, lowering it till the finger-tips touch the keys, and then continue this gentle lowering of arm till the forearm, wrist, and knuckles form almost a straight line, the knuckles standing just a little higher than the wrist by reason of the *very* gentle, yet firm, standing-up action on the part of the fingers.

For the first lesson, then, alternate the study of the hanging hand with that of finding keys quickly and surely all over the keyboard; and, as soon as possible, *combine* the two, carrying the loose hand up and down the keyboard in obedience to the eye, which picks out the notes. As we do so, let the *arm* invariably place the finger-tip over its key, the hand taking no *active* part. We shall take single notes thus, but shall not read from the paper, keeping the eyes rather for watching the arm, hand, fingers, and keyboard.



7.

Pick out thus, D's, C's, E's, B's, F's, A's, and G's. Let the hand hang limp from the arm; carry it about like a flail. When the finger-tip touches its note, let the forearm at the wrist descend to the normal playing position [7]. Lift the hand again by means of the arm, the finger-tip being loth to leave the key, and so *da capo* all over the keyboard. We may find it easier to work for a while with one hand and arm, then, resting this completely, continue the experiment with the other.

Knowledge of the Arm. The pianist must know his arm as intimately as he knows his instrument. The arm is jointed, and we can work its different portions singly or together. It has four joints. (1) Upper Arm (shoulder to elbow); (2) Forearm (elbow to wrist); (3) Hand (wrist to knuckles); and (4) Fingers. These are, again, jointed in three portions; but we shall, in the meantime, treat them as one.

These four portions of the arm can either support their own weight or hang limply; or they can, together and separately, be exercised downwards. The muscles that serve to lift or support them are distinct, or *opposite*, from those that lower them, and if the two sets are unnecessarily employed *together*, they become "opposing" muscles. We will call the lifting muscles the "up" muscles. When we wish either to lower or to let fall a limb (or part of a limb), or to exert it downwards, we must *not* use the *opposite*, or "up," muscles. If we let the hand hang quite loosely from the end of the arm [5], we have *relaxed* the *up* muscles of the hand.

Curved Line of Finger-tips. Now let us drop the hand in this way over the keys. Then gently lowering the whole arm, the longest fingers will first come into contact with the ivories, and will curve slightly palmwards as the wrist continues to descend. When all five fingers have reached the keys, we shall find that their tips form quite naturally a crescent curve. And if the fingers are properly doing their supporting work, fingers and hand together will form an arched dome over the keys.

The Knuckles. As we have seen, the five fingers on the five keys gently support the weight of the loosely hanging hand. We know that to do this *they must be slightly active*—active enough to cause the knuckle at the junction of finger and hand to protrude slightly upwards, rather than sink in. It is important to remember that *none* of the finger-knuckles should be permitted to sink in, neither the hand-knuckles, nor those nearest to the finger-tips. Bending the latter inwards is a common fault with beginners, and one which must be carefully guarded against and corrected.

The mere weight of the hand, supported by a very slight bracing up of the fingers, is insufficient to weigh down the ivory end of the see-saws, and so the hand may rest thus on the surface of the keys, without overbalancing them. This must be practised daily, resting on the surface of key with limply hanging hand. The student would

find it a great help to get a second person frequently to toss up the forearm of the player just at the wrist. The tips of the fingers would remain *resting* on the keys, to make sure that the hand was still left *hanging* free from the forearm, and had not locked itself—like the locking of the front wheel of a bicycle—into the condition prohibited, as in **6**. If this assistance is not available, the student should, just as a preparatory experiment, toss up the arm with the free hand.

Silent Keyboard Practice. And now, with the limp hand supported by the fingers resting on the ivory ends of the see-saws (but still not depressing them), the forearm, at the wrist-joint, should be swung gently up and down (without any help from the other hand), care being taken that the gentle resting weight on the keys, borne up from the tips of the fingers to the knuckles, is still felt. This *bearing-up* sensation in finger action is one that we must *never*, in all our playing experience, forget.

Matthay says: "The sensation accompanying all correct touch is that of work done upwards. In walking, standing, or running, you have a similar effect. It is true that your feet press upon the ground, but the exertion is *upwards*. And the moment you feel, at the piano, as if you were acting downwards, you may be sure you are employing the wrong exertions."

The second important maxim to be remembered is that the hand hangs loosely from the forearm, but it and the fingers may *bear upwards* by reaction from the keys.

The Key as Extension of the Finger. Matthay says: "The key is but a machine-lever, handle, or tool, to enable us to create speed in the string—an intimate elongation of our body."

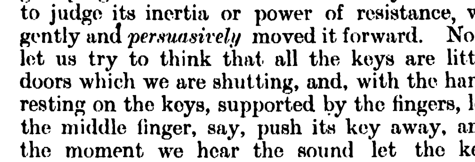
We have, so far, likened the key to a see-saw. Let us now use additional similes, and liken it to, say, a tennis racket, a cricket bat, or a golf club. Like these, it is a prolongation of the hand, a tool with which we hit the hammers against the strings, "to create speed in them," and so, in learning how to rest on the keys, we have learnt how to *take hold of our tool*. We must learn to move the key; and here, at the outset, it is evident that we must never *hit* our tool, but must rather take hold of it, and hit *with* it. "We must never aim *at* the key, but always *with* it."

And now, before learning to move the key, let us recall our first maxim.

Two-fold Use of the Key. The key has a two-fold function, therefore we have two separate and distinct things to do with it. We must (1) move it swiftly downwards to produce tone (hammer function). As soon as we hear the beginning of the sound the key's hammer-work is done. Then, if we wish (2) to prolong the tone, we must continue to lean gently (rest) on our depressed end of key, that its other end may continue to press up the stem of the damper, and so keep its felt-lined wooden head ¼ in. distant from the strings. It takes very little to hold the damper up, so for this purpose a very light resting on our end of key suffices.

Since the key has two functions, and it is best to learn one thing at a time, we shall try first with the finger how best to fulfil the hammer function of the key by *key-movement*. And let us, before trying with muscular activity and limb weight to move such a small thing as a piano key, try first an experiment on a larger scale with, say, an open door. The open door is the key, as at **2**; our action in closing it is analogous to moving a key down. We have shut a door ever since our toddling childhood, and learned to do it, therefore, in the days when we were keen experimenters. We found it was of no use to shut it sharply, but instead, leaning gently against it with the hand or body, in order to judge its inertia or power of resistance, we gently and *persuasively* moved it forward. Now let us try to think that all the keys are little doors which we are shutting, and, with the hand resting on the keys, supported by the fingers, let the middle finger, say, push its key away, and the moment we hear the sound let the key rebound. Try this repeatedly with one or other of the fingers. If we have used the finger in the easiest and most effective fashion against the key, we shall feel as though the impulse within the finger were an *upward* one—upward by reaction from the key and finger-tip to its hand-knuckle. "Action and reaction are equal and opposite"; therefore, what the finger-tip does to the key, its knuckle-end does equally, in the opposite direction, to the hand.

Recapitulation. Let us try this again—the hand hanging limp from arm, resting on finger-tips. The finger gently supporting this loose weight rests on the key, and feels resistance of the key as we should feel resistance of the door



8. THE DAMPER

A. Ivory key-end depressed
B. Damper off string
a. Ivory key up
b. Damper on string
c. String

we wish to move; then, pushing the key as we should push a door, set a see-saw in motion or move forward a swing with someone sitting in it, the feeling caused by this exertion of the finger will react upwards against the hand. We must *cease* this exertion the moment we hear the "*beginning* of the sound." The key will come up, the damper will go down, and the tone will cease. When we hear the tone thus suddenly cease, *we must not lift the hand off the keys*, although the key is now up, but let the hand still rest on the fingers, and each finger on its tool (key), ready to move one or another at will. Tones produced thus will all be short-lived, staccato and detached [8].

Sustained Tones. To produce sustained tones we must avail ourselves of the key's second function, its damper control. To keep a key down is as easy as to move it down at its softest.

Many pianoforte students, ignorant of the dual nature of the key's function, continue to use as much force against the key to keep it down as they used to move it down for a *forte*. To sustain a tone, however loud, we need do no more than lightly rest on the depressed key. The fingers must learn to keep the key down at their easiest. Try how gently we need rest on the keys to keep them down. It is the same kind of resting we did when the key was up, but *slightly* heavier.

Resting. We have learnt now the two kinds of "resting"—the resting that is not heavy enough to move the keys, and the resting that is just heavy enough to keep them down. These "restings," although they occupy so much of the time of the performance in a slow movement, are of the nature of waiting—waiting for the vivid movements of tone production—and are always the same, or vary very slightly. But the other thing we have to do to the key—the moving of it—must vary with every desired variation of tone. And the possible variations in this key-movement we shall now deal with. Tones may vary in (*a*) pitch, (*b*) quality, and in (*c*) quantity. For the pianist, the pitch of each note is fixed, but on his manner of using the key depends entirely the loudness and quality of the tone, and these can be affected by him only during the key-*movement*.

Tone-quantity. The pianist does not, like violinist or singer, *make* tone continuously—he makes tone in spurts and the instrument does the rest. As everything depends on these little spurts of exertion or impetus added to the resting, they must be accurately aimed. The key may continue its movement a little beyond the beginning of the sound, but must never be aimed past it. The key must be *aimed* to hit the sound, not to hit the little "buffer" pad beyond it. "The greater the speed of the movement of key, hammer, and string, the greater the tone-quantity produced by them"; so if we want a loud tone we must get up speed in the key-movement. If we want pianissimo (the very softest tone), the key must move as slowly as compatible with the production of sound.

Touch Formation. *Pianissimo* can only be obtained by the use of "weight touch," and is got by moving the key with the same slightly lapsed weight of the whole arm which provides the "resting" at bottom of keys for *tenuto* and *legato*. Try weighing down a common chord—say, C E G—thus. And now realise that, in doing this, we use a triple "muscular combination"—*i.e.*, finger exertion, hand exertion, and arm weight. All these three touch components may (1) be thus used together; or (2) we may eliminate arm weight and use only finger and hand; or (3) we may use finger exertion only "with loosely lying hand and self-supported arm." This last Mr. Matthay has christened first species of touch formation; the second (finger and hand) he has termed second species; and the other (finger and hand exertion and arm weight combined) he calls third species. Upon a thorough understanding and a proper application of these *three distinct species of touch formation* greatly depends success in pianoforte playing.

Now, "*ppp*" is evidently third species, for in it the key is moved down by the lapsed weight of the arm levered on to the keys by the exertion of the fingers and hand. Weight and exertion alike are in this case very slight. In producing tone thus, we have produced it at its very softest. At the same time the biggest tone obtainable from the instrument is got by the same triple combination—*viz.*, (1) arm weight levered on to the keys; (2) finger; and (3) hand exertion; but in this case the exertion and the weight are alike proportionately greater.

When we use only finger exertion with hand weight (first species) we can get great agility with little tone. When we use finger with hand exertion behind it, and hold away the weight of the arm (second species), we get less speed and more tone; when we use finger and hand exertion and more arm weight than for "*pp*," we get large tone, but still less speed.

Thus, roughly, we have dealt with tone-quantity and speed across the keyboard.

Tone-quality. The way in which key movement *is started* greatly affects the tone-quality. Thus a suddenly started movement gives us a hard, brilliant, clean-cut sound, whilst a more gradually started movement yields a full sympathetic tone. To be artists we want mastery of both qualities, and of all gradations of them. This mastery depends largely on our capacity for easy muscular discrimination. We must learn to use the different parts of our pianoforte limbs independently, or combine their actions and inactions at will. It may help us here to think of our fingers as little legs, and to imagine these miniature limbs running, walking, stepping up stairs, or running down hill, while the loosely lying hand is the body which they must always carry. The loose weight of the arm, on the other hand, is a burden which they may carry or not at will, a burden that may be thrown off when the little legs want to run very fast or very lightly—*i.e.*, *prestissimo* or *leggierissimo*. Now we must learn the trick of burdening and unburdening these little legs and bodies, letting in or lifting away the weight of the arm. As we learnt alternately to support and relax the hand, we must now learn to do so to the whole arm.

Arm Control Exercises. (1) Hanging limply from the shoulder, let the arm be tossed about by an external agency (our own free arm or that of a second person); let it remain perfectly passive, therefore limp.

(2) Now, resting the fore-arm horizontally on another arm, learn to distinguish these three possible different conditions: (*a*) actively pressing the arm down on another (using the down muscles of the arm), a condition never to be employed in our present stage in pianoforte playing, and later only very slightly at times—it would crush and lame and impede the movements of the nimble little runners; (*b*) merely letting our arm be in contact with the other, without really resting on it at all (using the up muscles of the arm)—this would lift the

burden completely off the little body and legs; and (*c*) resting the whole limp weight of our arm on the other (completely relaxing all the muscles of the arm), a very necessary condition at times, and one that must be induced, during key-movement, for really big tones of any kind.

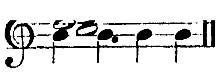
Let us work at this till we perfectly realise the three sensations: (*a*) Pressing down, almost invariably bad; (*b*) merely touching without real resting—necessary for agility passages; (*c*) letting the loose weight of the arm rest—this to provide the little spurts in big tone key-movement (called third species of Touch formation). Let us experiment with other people. Children usually master these willed variations in muscular condition much more quickly than adults. Do not let us confuse the required passive heaviness of relaxed resting with the undesirable active down pressure of the muscles of the arm, nor the stiffly rigidly held arm with correct gentle support.

The arm has four portions, and in the action and interaction of these different portions what the finger is to the hand the hand is to the forearm, and what the hand is to the forearm the forearm is to the upper arm, and so also the upper arm to the shoulder. It is always a case of one joint further removed from finger-tips. And, having recognised the general sensation of muscular conditions—*i.e.*, muscular *action* (limb supporting itself), and muscular *inaction* (limb hanging limp)—we must learn to locate and practise these in the separate portions of the arm. In such experiments, lift the portion gently; to feel its weight, balance it up and down, alternately lifting and letting it fall; then, finally, relax the upholding muscles entirely and drop it.

General Principles of Relaxation Exercises. Remember the general principles of all such exercises: (*a*) *Gentle* contractions for lifting or supporting a limb or part of a limb; (*b*) absolutely loose, uncontrolled relaxations, allowing it suddenly to fall again at a definite moment of time. Such practice is more mental in its aim than physical—*i.e.*, it is not so much for the sake of strengthening and making flexible the *muscles*, as of training the *mind** to recognise and easily recall the sensations accompanying divers muscular conditions, and to make the limbs obey the will.

Technics at the Piano. Now let us return to the keyboard and apply this, taking any simple finger exercises. Such materials (technics) should always be memorised.

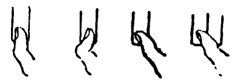
A time-honoured form, to be found in most collections, is this: Take the long notes here as representing a resting on the *top* of the normally undepressed key; do not depress them to their low level. With the



moving finger do not try to push the key too far down, endeavour to work only "to the sound"; remember that the hammer reaches and propels the string just before we reach the key-bed felts. Experiment with different degrees of relaxed weight behind the fingers, and always see to it that the fingers' *work* feels *upwards* by reaction from the key. In using much weight behind the fingers, practise at first invariably staccato, and so let the weight be *unconsciously* caught up again by the upholding muscles of the arm.

If, when first practising with much weight, we play tenuto or legato, we shall risk letting the big weight of the loose arm *continue* to be a burden on the fingers, and this it must *never* do, as it would result in key-bed squeezing, and ruin our agility and powers of expression.

Equalising the Fingers. We must now try to equalise the fingers in the exercises; we must get the same quantity and quality of tone from each finger. The thumb is very apt to force down; try to get with it also the sensation of playing "up" towards the hand. Its best *position* is that with the nail-joint in line with the key, thus (*a*), not obliquely across it, thus (*b*), or (*c*). Of course, when two adjacent notes are to be sounded together by the thumb, its nail-joint must then lie obliquely to the two keys (*d*). The whole thumb in the normal position should be held well away from the hand. We shall probably find that the fourth and fifth fingers of the hand seem to be the weakest, and we shall want to know how to strengthen them, how to make them "equal" with the other fingers.



a *b* *c* *d*

Rotary Adjustments. In the forearm we have two long bones which can roll over each other, enabling us to rotate the forearm and with it the hand. We can thus turn the hand either palm upwards or palm downwards, or merely tilt it from side to side—a *rotary* motion of hand and fore-arm, a movement of the wrist round its centre, like that of a wheel round its axle. But we have seen already in the case of motionlessly upbearing fingers and loose lying hand that there can be muscular action and inaction without any visible *movement*.

The muscular habits of this forearm rotary control form no exception to the rule. We may visibly rock the hand to and fro, thumb side to fifth finger side, and vice versâ, with a rotary movement (as we do for certain tremolo effects), slightly rolling the fore-arm.

But, when we wish it, we can summon these rotary muscles to our service *invisibly*. We can relax the muscles that hold up the hand at one side or the other "rotarily," and the hand can then be made to tend to fall to either at will. In this way, weak fingers, making use of the weight which is tending to fall, will bear up against it, and at the same moment bear equally against the key, and, moving it swiftly down, produce a good tone. We can also make use of rotary *exertion*. At the weak finger side of the hand, then, use "rotary adjustment," remembering *only in proportion as we bear up with the finger against this rotary tendency to fall do we bring the weight to bear effectively on the keys.*

M. KENNEDY-FRASER

Another Examination of Fibres. The Bast Group. How Micro-Photographs are obtained.

FIBRES UNDER THE MICROSCOPE

For microscopic purposes, the whole group of bast fibres may be considered together, for the simple reason that they have many things in common. They all differ entirely from cotton, with its spiral formation, and from wool, the surface of which is covered with scales. They also differ enormously in length from these two important fibres, for it is a common thing to find fibres from four to seven feet long in jute, from six to twelve feet long in hemp, and from thirty to twelve inches long in linen.

Bast fibres are themselves composed of filaments, or cells, which are very narrow, but relatively very long. These are by no means easy to see under the microscope, and even when this is possible, it is not easy to distinguish fine hemp from coarse linen, or fine jute from coarse hemp. Although they are the product of different plants, jute and hemp, hemp and flax resemble one another to an extraordinary degree, and only those who have spent a great deal of time in a specialised study of the subject can expect to distinguish one from the other by means of the microscope alone.

Linen. Linen is the finest and most valuable of all the fibres which are derived from the stems or leaves of plants. The fibre, as we have already seen, is taken from the inner bark, and is separated into very fine, long threads by the process called retting. Weisner gives the length of flax coming from various countries as in the following table.

	Length	
	Inches.	Millimetres.
Egyptian	38	960
Westphalian ..	30	750
Belgian	15	375
Austrian	16	400
Prussian	11	280

It may therefore be taken that good flax should average at least 20 inches in length, and it should be free from fibres that are less than 12 inches long. When imperfectly retted, the fibres occur in groups which may be $\frac{1}{100}$ or more of an inch in diameter, but when they are completely separated it may easily be seen from [1] how very small the individual fibres are. There they appear to be about $\frac{1}{20}$ of an inch in diameter, and as the photograph is magnified just 80 times, their diameter would really be $\frac{1}{20}$ multiplied by $\frac{1}{80}$, or $\frac{1}{1600}$ of an inch.

These fibres are built up of still smaller filaments, which vary in length from 25 to 30 mm., but so fine in diameter are they that they only measure ·012 to ·025 mm., which gives a ratio of length to breadth of fully 1200 to 1. The larger fibres which are thus built up taper to a fine point at both ends. Their colour is for the most part yellow, but flax retted in stagnant water may turn to a steel grey.

Like nearly all the fibres derived from the stems of plants, when examined under the microscope fine transverse markings may be always observed on the surface of the flax. Sometimes dislocations, or nodes, are apparent, and they may be made still more visible for examination by staining the fibre with methyl violet. Each fibre contains a central canal, but it is often so small that it is only apparent as a faint, dark line when the fibres are magnified 80 times. In section, the fibres are not round, like wool or silk, but polygonal, with many irregular sides, which give an additional means of distinguishing them from cotton or wool. On the other hand, they very strongly resemble hemp, jute, ramie, and Manila, and the student must be careful in making deductions when examining different bast fibres.

Hemp. True hemp fibre, the product of the stem of the *Cannibis sativa*, although it belongs to a different genus, possesses fibres extremely like those of flax. In hemp the filaments of which the fibres are composed vary in length from 15 to 25 mm., while their diameter is about ·022 mm., making the ratio of length to breadth of 1 to 1000. Like linen, each separate fibre is faintly marked across with dislocations, or nodes, but in addition the surface is marked with fissures in a way that is extremely rare in the case of linen [2].

It is a curious fact that the various types of fibre sold as hemp resemble one another very strongly, in spite of the fact that the plants from which they come are widely different in character. Sisal hemp is from an agave with fleshy leaves, while Manila is the product of a wild plantain. In some kinds, notably in Gambo hemp, the fibres are no less than five to six feet in length. The ends are generally blunt, the central canal is wide in places, but so fine as to resemble a line near the point. The chief difference between hemp and linen lies in the fact that hemp fibres have fine forked ends. They are less transparent, and the surface of the various fibres is often striated.

Manila Hemp. Manila hemp is principally used for the making of cordage because of its great strength, and also because of the fact that individual fibres are frequently found from six to twelve feet in length. The diameter of these individual fibres varies from $\frac{1}{600}$ to $\frac{1}{1700}$ of an inch, and their colour is buff and lustrous. Although it is easy to separate every fibre from its neighbour by treatment in a bath of alkali, they are more often seen in bundles of considerable diameter, for which reason Manila

hemp appears coarser than linen, although the measurements of separate fibres are almost alike.

The microscope shows that the walls are thin and the central canal large and distinct. Fibre bundles often show a series of peculiar and strongly marked plates, and the canals often contain yellow colouring matter, though no median layer is perceptible between the fibres. Like other fibres of the same class, it may be separated into its ultimate cells, or filaments, and in the dimensions of these it differs considerably from true hemp, for they vary from ·016 to ·030 mm. in diameter, but only from three to twelve millimetres in length. This gives a ratio of 1 to 250, which is only about one-fourth part of that of true hemp.

Jute. Jute is obtained from plants of the genus *Corchorus*. There are two species which are cultivated for fibre, and, though they are botanically distinct, the fibres from the two plants are practically identical. In length the fibres vary from four to seven feet, and in diameter they are about $\frac{1}{800}$ of an inch. When examined under the microscope [3] they have every appearance of being valuable for the production of textile fabrics, and it is only when the structure of individual fibres is considered that the reason for their disappointing character is discovered. The ultimate filaments of which they are composed are only from one to five millimetres in length, and from ·020 to ·025 mm. in diameter. This means that the ratio of length to diameter is only 90 to 1, and this shortness of the filaments has a serious effect on the spinning value of the fibre.

Seen in section, the filaments have many rectangular sides of different length, with sharply defined angles. In colour the fibre is pale yellow to silver-grey, and the central canal—which is sometimes one-fourth the diameter of the whole fibre—has constrictions which make it almost invisible. The fibre is much less pure cellulose than is the case in hemp or linen. It approaches much more nearly to the condition of wood, and is known as bastos or ligno-cellulose.

Ramie. We have seen that ramie, rhea, and China grass are really one and the same, and it is impossible under the microscope to see any difference between samples marketed under the three separate names. The size of the filaments of which ramie is composed has led many theorists to believe that there was a very great future in store for these fibres, for it is possible to find whole fibres ·080 mm. in diameter, and ten inches in length, which consist of a single cell, or filament. Unfortunately, their diameters are very irregular. Sometimes they occur with heavy cell-walls and a well-defined central canal, at other times they are broad and flat with badly defined central markings. Usually they have heavy striations, and at times the dislocations of the nodes are exceedingly large and irregular in size. The fibre is apt to bend at these places, which may be three times the normal diameter. The fibre itself, as will be seen from the photograph [4], is exceedingly transparent; it is, in fact, pure white, without trace of colouring matter except in the central canal, where at times traces of granular matter may be seen.

Silk. In reserving the description of the silk fibre to the last, we are not by any means according it its proper place, for it is by far the strongest, finest, and most lustrous of all the fibres. Yet microscopically it is relatively uninteresting. Formed as it is of hardened jelly, it is practically impossible for the most powerful microscope to see any trace of structure within it. The surface also is perfectly smooth, without any distinctive features, so that it is actually by the absence of markings, which occur in all other fibres, that it may most easily be detected. The fibre is also exceeding small in diameter, $\frac{1}{2000}$ in. being a common size.

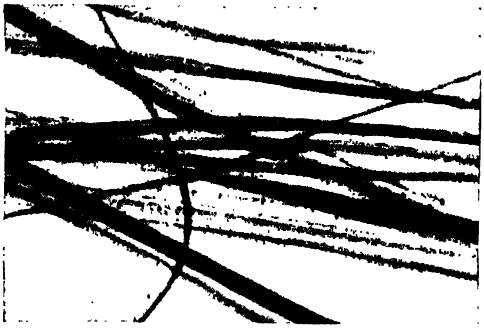
In raw silk there are nearly always two fibres side by side, which are frequently covered with an envelope of sericin. This may be perfectly smooth and homogeneous, with a faint outline; it may exhibit small cracks and folds at intervals, or it may be altogether lacking at certain parts of the thread. The only fibre that silk really resembles in its appearance under the microscope is artificial silk, and from that it is easily distinguishable on the ground of diameter alone.

Fibres which have been taken from silk fabrics of any description will always appear as single strands—that is to say, they will never be in a condition of a two-fold thread, glued together by a covering of sericin. Each fibre is almost round in section, and although slight faults may occur at different points, such as those to be seen on one of the fibres in the illustration [5], they are for the most part remarkably free from defects, running for long distances without any roughening of the smooth and brilliant surface. In an undyed condition they are wonderfully transparent; they are practically invisible when immersed in balsam solution, so that anyone who is desirous of making a careful examination of them must dye them before mounting them for a permanent microscope slide.

Artificial Silk. This is so much larger in diameter than real silk that no microscopic worker is likely to mistake the one for the other. But, apart from its diameter, artificial silk has features which are quite absent in the natural fibre. At present there are three entirely different kinds. First, there is the original *nitro-cellulose* [6], the surface of which is quite smooth, but not very round in section. Fibres of this material very often show a central canal, and when they vary in diameter, as is frequently the case in single threads, it is the smaller ones which appear the roundest and most solid.

Almost all the same facts are true of *cupro-ammonium* silk, but the fibres are larger in diameter [7] than those already mentioned. The central canal is, if possible, more definite, though it is more irregular in diameter. The third type is known as *viscose* silk [8]. It differs from the others in all respects. The fibres are flatter and wider than either of the foregoing types, and they show no central canal. It is just possible that such a canal exists, for the surface of individual fibres is so much striated that it is impossible

CHARACTERISTIC MARKINGS OF FIBRES

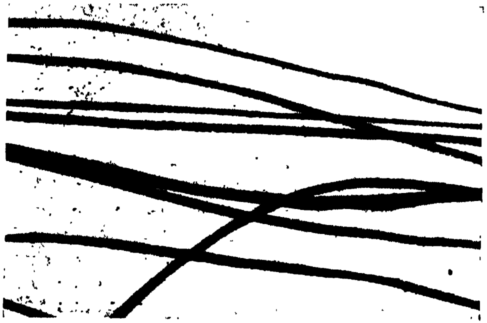


1. Linen, showing the transverse markings and the extreme fineness of the fibre.

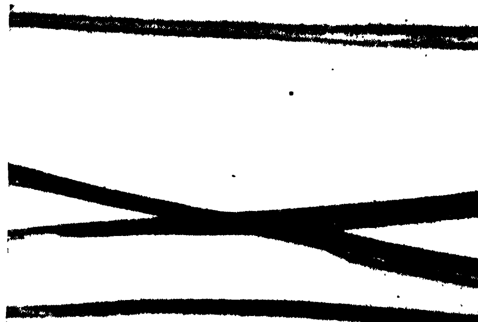
2. Hemp, the fibres being arranged in groups and single strands, and showing surface markings and fissures.

3. Jute, showing how much coarser the structure appears when it has been dyed than that of hemp.

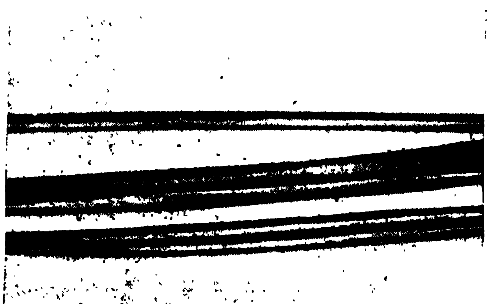
4. Ramie, showing the surface markings and the (treme transparency of the fibres, with their dislocations



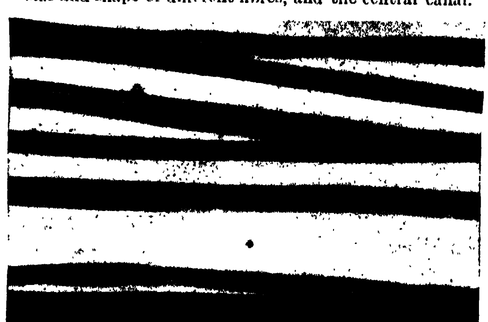
5. Silk, showing smooth and regular surface of fibres from a four-thousandth to a two-thousandth diameter.



6. Nitro-cellulose Silk, showing irregularity in the size and shape of different fibres, and the central canal.



7. Cupro-ammonium Silk, showing the central canal in two examples of one four-thousandth of an inch diameter. The small fibre was only one nine-hundredth of an inch.



8. Viscose Silk, showing the strongly striated surface, which makes it impossible to see the central canal. The diameter of these examples was about one-640th of an inch.

to see the nature of the structure within the outer skin of the fibre.

The fact that this fibre has a finely fluted surface, and is still the most lustrous of the three, raises a very interesting question in textile optics. Previous to the discovery of the Schreiner process for giving lustre to certain goods by the use of finely fluted rollers, it was always considered that a smooth surface and smooth fibre were more lustrous than rough ones. The extraordinary lustre of viscose silk gives additional support to the theory that a finely fluted surface has even more brilliance than one which has a perfectly smooth surface, for there is no doubt whatever that viscose silk is not only the strongest but the most lustrous artificial silk yet made.

The characteristics of all three are easily visible under a microscope of a comparatively low power, and as artificial silk is rapidly coming into daily use in the manufacture of such things as neckties and ribbons, it becomes increasingly necessary that the public should have at their disposal some means of distinguishing it from the genuine article, which is worth—if it does not cost—about ten times the price.

How Diameter Influences Value. The size of the fibres of artificial silk is in almost inverse ratio to their value as compared with the product of the silkworm. Fibres of the best Italian silk are $\frac{1}{2200}$ of an inch in diameter, good China silk being $\frac{1}{1800}$ of an inch. As compared with these figures, single fibres in a 200 denier cupro-ammonium silk are only $\frac{1}{680}$ to $\frac{1}{510}$ of an inch. In viscose they vary from $\frac{1}{500}$ to $\frac{1}{440}$ of an inch, while those of nitro-cellulose range from $\frac{1}{510}$ to $\frac{1}{450}$ of an inch in diameter. On an average, therefore, real silk may be taken as $\frac{1}{2000}$ of an inch in diameter, while the artificial product is $\frac{1}{510}$, giving an average of not quite four diameters to one.

The point of really practical importance, however, is not the diameter of the fibres, but their number in a thread of any given size. The one has, of course, direct bearing on the other, but the two are not in direct relation. We should expect to find them in exact proportion to the square root, and their actual dimensions come exceedingly near to such a relation. In a 39 denier China silk there are 31 fibres, which means that in a 200 denier of the same material there would be 159 fibres, while a 200 denier cupro-ammonium silk contains only from 16 to 18 fibres. The same sized thread of nitro-cellulose contains anything from 16 to 26 fibres, viscose having from 20 to 23. This makes the average of all the artificial silks to be 19½ fibres in a 200 denier thread, showing that real silk, even if it be not a very fine one, will contain no less than eight times the number of fibres in a thread of the same weight.

Making Micro-Photographs of Fibres. The possessor of a microscope who once turns it to the examination and identification of textile fibres is sure to wish to make micro-photographs for himself. The work presents less difficulty than many persons imagine.

To those who are unacquainted with the possibilities of micro-photography, it may seem an exceedingly difficult, if not impossible, task to measure anything so small as $\frac{1}{30000}$ of an inch, and it may, therefore, be as well to give some account of the way in which photographs are made and used to obtain such results. It is done by a double magnification. First, a micro-photograph is taken, and this in turn is examined under another microscope. It is a very common error to suppose that the difference between the actinic and the visual focus, which exists in every lens, is particularly exaggerated in microscopic photography, and must be overcome by an alteration in the position of the ground glass, after an accurate focus—as judged by the eye—has been obtained. Such an alteration is wholly unnecessary if isochromatic plates are employed, provided always that the fibre to be photographed is coloured red, and provided also that the objective which is being used is suitable for the purpose. Without trenching on the course on Optics, it may be stated that the actinic and visual foci of red are so nearly alike that no alteration ought to be necessary when once a sharp image of a red slide has been focused on the ground glass.

The difficulty which stands in the way of any very great enlargement of wool fibres by photography is their comparatively large diameter, and the frequency with which their curly nature makes them cross one another when they are mounted on a microscopic slide. However carefully the dyeing, dehydrating, and mounting in balsam may be done, a slide which contains more than one or two fibres is nearly sure to have a large percentage of the fibres crossing one another at different places. To obtain a large number of measurements and to save time in making slides, it is necessary that each slide should have a large number of fibres upon it. It is necessary that all should be in focus at one time, even in places where two fibres are superimposed.

How High Magnification is Secured. This makes it desirable to use a lens of comparatively low power, because to say that a lens is of low power is practically synonymous with saying that it is of deep focus. To get large magnification with low power it is only necessary to use a very long camera.

Having once obtained a negative by this means, it is examined under another microscope having a micrometer eyepiece. If the objective is approximately of an inch focus, what was originally $\frac{1}{1000}$ part of an inch will now cover about thirty divisions of the micrometer eyepiece. In other words, with a photograph taken in this way, examined under the lenses here named, each division of the micrometer eyepiece will be equal to $\frac{1}{30000}$ of an inch, whatever object or slide is being examined by this method. Under this system it is only necessary to keep a record of the lenses with which photographs are taken to ascertain with accuracy the size of any object photographed, or the size of any part of the same.

HOWARD PRIESTMAN

The Nature and Orbits of Comets.
Aerolites. The Ill-omened Meteorites.

COMETS AND SHOOTING STARS

In addition to the planets and their satellites, the sun is attended by numerous other bodies, moving with far less regularity, and generally much less conspicuous in the heavens. These are known as *comets* and *meteorites* or *shooting stars*. One of the most interesting of recent astronomical discoveries is that an intimate physical connection exists between these two classes of bodies.

Comets. Comets have been known from the earliest times, because every now and then a very large and conspicuous one hastens up to the sun from the remote regions of space, and perplexes monarchs with the fear of change. They are called *comets*, from the Latin *coma*, meaning hair, because when they are bright enough to be seen with the naked eye they look like stars attended by a long stream of hazy light, which was thought to resemble a woman's hair flowing down her back. This train of light is known as the comet's *tail*. Such bright comets are sometimes as brilliant as Venus; their tails have been known to stretch halfway across the visible sky.

These comets are very beautiful and conspicuous objects, which usually appear in the sky without any warning from astronomers, and invariably create a great popular sensation. By far the greater number of comets, however, are only visible through a telescope, and it is rare that a year passes without at least half a dozen of these being reported. Up to the present time nearly a thousand comets of all sizes have been recorded. Not more than one in five of these visitors is visible to the naked eye.

Cometary Orbits. In all cases in which a comet has been observed sufficiently often for its orbit to be calculated, it is found that it moves in one of the curves which are known to the geometer as conic sections. Less than a hundred of the known comets move like the planets in *elliptical* orbits, and consequently their periodical return to visibility can be predicted. As a rule the eccentricity of these cometary orbits is very much greater than that of any planetary orbit, which means that the comet approaches fairly close to the sun at one end of its orbit, but at the other flies away far beyond the outermost planet, and for a long period disappears from the ken of our most powerful telescopes.

The great majority of comets have only been seen once, and their orbits appear to be either *parabolic* or *hyperbolic*. Neither of these is a closed curve, and what seems to happen in such cases is that a comet travelling in such an orbit dashes up to the sun from the remote parts of space, swings round it, often at very close quarters, and flies away again for ever. Only those comets which have elliptical orbits can be said to belong to the solar system. The others are visitors from space, which in the course of their motion come near the sun and are deflected by it, but then fly away until after a lapse of ages they perhaps come within the sphere of another star's attraction. Of the comets which move in elliptical orbits, about twenty have been observed at more than one return to the sun. Some of these complete their orbits in quite a short period, like Encke's comet, which has the shortest period of all, less than three and a half years; the longest periodical comet is known as Halley's, which returns to the sun after 76 years, and last appeared in 1910; it is a bright and conspicuous object.

The Constitution of Comets. The nature of comets was long in doubt, and even today their physical characteristics are not fully understood. They are certainly formed of gravitational matter, because they move in orbits which are subject to the same laws as those of the planets. But they also appear to be acted upon by powerful *repulsive forces* emanating from the sun, to which is due the remarkable phenomenon of cometary tails. At first it was supposed that a comet and its tail consisted of what we know as solid matter. But the observed facts are quite inconsistent with this theory.

A comet's tail, which stretches for many millions of miles, is always directed away from the sun, and when the comet swings rapidly round the sun the whole of this tail follows its motion in such a way that it is quite impossible to suppose that it consists of any kind of matter with which we are acquainted. The probability is that these tails consist of highly rarefied matter thrown off from the comet under the influence of a repulsive force emanating from the sun which is probably electrical in its nature. The degree of rarefaction of the matter composing these tails is probably greater than that of any vacuum which we can produce in our laboratories, and its luminosity is due to similar causes to those which produce the glow in a vacuum tube through which an electric current is passed. (See page 742.)

The Wonder of the Tail. The extreme tenuity of comets is proved from the facts that the earth is known to have passed right through the tail of a comet without any apparent effect, that the close approach of a comet to a planet causes no apparent alteration of the planet's motion, and that small stars can be seen shining brightly right through a comet as much as 100,000 miles in diameter. Perhaps there is not much exaggeration in the statement once made by a well-known astronomer that the whole material of a comet stretching halfway across the visible heavens, if properly compressed, could be placed in a hatbox. The old fear that the earth might suddenly be annihilated by a comet striking it is thoroughly dispelled by modern

investigation, which leads us to believe that the worst results of such an encounter would be an extremely beautiful display of shooting stars.

Meteorites, or shooting stars, have been known to mankind from the earliest times, though it is only of late years that their intimate association with comets has been discovered.

Aerolites. Shooting stars must be divided into two classes. There is the solitary *fire-ball* or *aerolite*, which sometimes assumes very respectable dimensions, like that which burst over Madrid some years ago, or that which once strewed the plains of Arizona with vast masses of meteoric iron. These visitors can never be predicted, though few nights in the year pass without one or more of them being visible to the careful watcher of the skies. They are masses of rock, chiefly consisting of pure iron, which collide with the earth as it travels through space, but are fortunately prevented, as a rule, from dashing against its surface by the convenient buffer interposed by the atmosphere. The resistance of the air, which is practically experienced by cyclists struggling with a head wind, increases very rapidly with the velocity of a body moving through it. It is the most serious factor in the flight of a modern projectile, and a meteorite which enters the air with a velocity of many miles per second is promptly raised to such a temperature by the atmospheric resistance to its motion that it is rendered incandescent and dissipated into vapour or dust, unless its size is very great. In the latter case it breaks up into a number of small pieces, with a flash and a report which is sometimes heard on the surface of the earth, and these pieces may ultimately reach the ground.

Many specimens of such aerolites are to be seen in the Natural History Museum at South Kensington; the Sacred Black Stone of Mecca and the image of Diana, which was said to have fallen from heaven at Ephesus, are believed to be the remains of such meteorites. But, as a rule, visitors of this kind are entirely consumed in the upper regions of the air. The *luminous streak* which they leave behind them as we watch them on a clear night is composed of their disintegrated dust raised to incandescence by the friction of the air. This dust slowly settles down upon the surface of the earth, and is frequently met with in the ooze of the deep seas and among the sands of the deserts. It has been estimated that between 1,000,000 and 2,000,000 of these shooting stars are encountered by the earth in every twenty-four hours. If it were not for the atmosphere we should be bombarded by these projectiles in a fashion far more perilous than any known to Port Arthur or Adrianople.

HALLEY'S COMET, PHOTOGRAPHED IN MAY, 1910, AT YERKES OBSERVATORY

Star-showers. In addition to these solitary and mostly invisible aerolites, the earth encounters meteor swarms which are of periodical occurrence. The most conspicuous and famous of these are the November meteorites, known as the Leonids, which used to give rise to a wonderful display of celestial fireworks once every thirty-three years. From very early times men have recorded the fears produced by the contemplation of this wonderful and brilliant onset of stars shooting madly from their spheres. In 1833 the negroes of the Southern States were quite persuaded that the end of the world was at hand. The sky was said to be as full of shooting stars

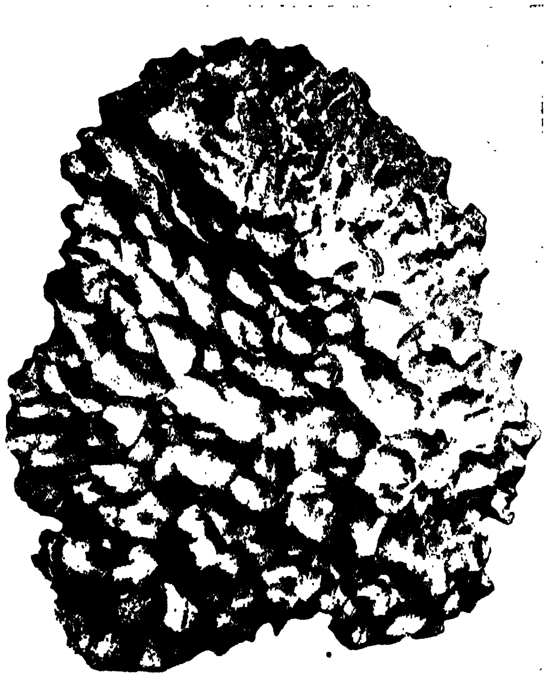
THE MOORHOUSE COMET OF THE AUTUMN OF 1908

THE COMET OF JANUARY, 1910, WITH STARS SHINING THROUGH IT

as it is of snowflakes in a winter storm. These shooting stars reappeared in 1866.

Something has recently gone wrong with these Leonid meteorites, and the display which was confidently expected about 1899 never took place. There are several hundred of these meteor-showers known to astronomers, and hardly a week in the year passes when one or more of them is not due. Each shower is recognisable by the fact that it seems to come from a particular place in the heavens, and it is usually named after the particular constellation from which it comes. Thus the two chief November star-showers are the Leonids, coming from the constellation of Leo, and the Andromedes, coming from the constellation of Andromeda. A star-shower due about the 10th of August, popularly known as the tears of St. Lawrence, consists of the Perseid meteorites, coming from the constellation of Perseus. The point from which any particular star-shower appears to come is known as its *radiant*, and is found by tracing the path of each observed meteorite upon a star chart; the point in which all these paths meet—in other words, their vanishing point—is the *radiant point*.

Meteoritic Swarms. Many of these star-showers occur year after year on the same night, while others, like the November Leonids, occur on the same night at intervals of many years. There is only one plausible explanation of this.



MATTER FROM ANOTHER WORLD

This photograph is of a piece of ore that has fallen on our earth as a meteorite, which proves on analysis to be composed of the same materials as those which comprise the earth.

The shooting stars which become visible by contact with our atmosphere on a particular night in the year must belong to a swarm of such bodies travelling round the sun in a definite orbit, which intersects the orbit of the earth at the point which our planet reaches on that night. At every meeting a considerable number of these minute bodies are sacrificed by contact with the earth, but their number is so great that there seems to be no appreciable diminution in it. If the meteoritic swarm be distributed with evenness along the whole of this orbit, there will be, as a result, a display of shooting stars of pretty much the same brilliance every year. In the case of meteorites like the Leonids, which only appear once in thirty-three years, the main body of the meteorites must be concentrated into a swarm which travels round its orbit at such a speed that it only passes the earth's orbit while the earth is in that neighbourhood once in thirty-three years. The explanation of the failure of the Leonids to appear when they were last due is that some external cause has changed their motion by perturbing their orbit so that now they just miss the earth. The orbits of a considerable number of these meteoritic swarms have now been calculated—a wonderful achievement when we remember that they can only be studied in the brief instants in which they are burnt up by the contact with our atmosphere. Soon after the great shower of November meteorites in 1866, it was shown by an Italian astronomer, Schiaparelli, that the orbit which has been assigned to the Perseids or August meteorites was identical with that of a comet which had been observed in 1862. Soon afterwards the orbit of the Leonids or November meteorites was also calculated, and it also turned out to be identical with that assigned to a comet which had been discovered by Tempel in 1866. Next the Andromeda meteorites, which meet the earth in the latter part of November, were found to move in the track of Biela's comet. Since then at least five other meteoritic swarms have been found moving in orbits recognised to be coincident with those of comets.

It is impossible to suppose that all these coincidences are accidental. It is now believed that a comet is simply a meteoritic swarm, and that when it disintegrates—as more than one comet has been seen to do—it breaks up into a crowd of meteors, which tend to be scattered gradually more and more thinly along its orbit, until in the lapse of time there results an orbit covered with a thin ring of flying meteorites. Some are sufficiently large to endure the intense heat which they undergo in passing through the atmosphere and still reach the earth as a solid mass. At least once or twice many tons of solid iron have thus been precipitated to the earth.

W. E. GARRETT FISHER

Theory and Laws of Friction. Mechanical Uses of Friction, including Brakes, Belt-hammers, Clutches, Gears, Shafting, Belts.

FRICTION AND ITS APPLICATIONS

No substance exists which has, or can have, a perfectly smooth surface. The polished face of a piece of wood or stone, or the surface of glass, is covered with minute roughnesses, although this unevenness is imperceptible to the senses of sight and touch. Thus, when two surfaces are in contact, the multitudinous protuberances interlock, resisting both the setting in motion and the continuance in motion of one surface over the other. This resistance is called friction. It destroys but cannot generate motion, and it acts always in the contrary direction to that in which the body is moving.

Friction in Use. How does the engineer regard friction? Sometimes this force acts as a valuable ally in promoting the stability of a structure or in assisting the work of a machine, and it may even be necessary to assist this force in its tendency to resist slipping. To friction we are indebted for the action of the driving-wheels of locomotives, for they would otherwise slip on the rails and make no progress; for the action of cords and straps round pulleys and drums; for the gripping power of a vice; for the arresting power of a brake; and so on.

Sometimes, however, friction is distinctly disadvantageous, and presents an obstruction to the efficient working of a machine. The ingenuity of engineers is then called into play to reduce its inimical tendency. Thus, roller and ball bearings assist the rotation of a shaft, while oils and tallow are extensively used as lubricants. Even then continual friction gradually abrades the hardest material, and so, in a machine where two parts are exposed to friction, that one which can be more easily or cheaply replaced is made of softer metal, so that it may receive the greater degree of wear.

Kinds of Friction. The force tending to prevent the setting in motion of two bodies at rest is called *static friction*, and the resistance tending to arrest the motion of one body over another is *kinetic friction*. A distinction is also drawn between *rolling* friction, as in the revolution of a cart-wheel, and *sliding* friction, as in the motion of the same wheel going downhill with a skid on. It might be thought that the resistance between any two surfaces would be similar, whether they are at rest or in motion, but we shall see that this is not so. The word friction (Lat. *frico*—I rub), used in the statical sense, is scarcely exact, for there is no rubbing until motion begins.

How to Measure Friction: Coefficient of Friction. The amount of static or kinetic friction between any two bodies may be measured by a simple experiment. Suppose it is required to measure the frictional resistance between the weight W [48] and the surface A B along which it slides. The cord runs over a delicate pulley (C), and is attached to the scale pan. Weights (P) are gradually added until W starts moving. The weight required to do this measures the friction between the surfaces; that is, P = the frictional resistance. In this experiment W = 10 lb., and P = 4 lb. Thus the ratio between the friction and the weight $\frac{P}{W} = \frac{4}{10} = \cdot 4$. This friction is called the *coefficient of friction*, and if W and A B were composed of oak, then $\frac{4}{10}$ or ·4 would be spoken of as the coefficient of friction for oak on oak.

The coefficient obtained in this experiment should more correctly be termed the static coefficient, because P measures the greatest frictional resistance the bodies are capable of offering to a sliding force when at rest. If the surface (A B) is sufficiently long, it will be found that a *less* weight will be necessary to cause W to continue in uniform motion along A B if this steady motion is started with a slight push of the finger.

Static and Kinetic Friction Compared. In other words, static friction is greater than kinetic friction. A horse which has a difficulty in starting a heavy load pulls it with comparative ease once it is in motion. Actual experiment has shown that the static coefficient of dry wood on dry wood is ·50, but the kinetic coefficient is only ·36; similarly, the coefficient of dry wood on metal is ·60 at rest, but when in motion, ·42. If in this experiment the student substituted other substances and other surfaces, it would be found that a less weight or power would be required to start W in motion when the surfaces were smooth, and a greater power when the surfaces were rough. Hence, the fraction $\frac{P}{W}$ would become greater or less, according as the frictional resistance was greater or less. So we find that the coefficient of friction of wrought iron on oak is ·62, but that of steel on glass is ·11; of brick on brick, ·64; but polished marble on polished marble, ·16.

Another and simpler method of finding both static and kinetic coefficients is shown in **49**. W is the weight resting on a board (A B). One end of the board is very gradually raised until W slides down with uniform motion (for determination of kinetic friction), or until the weight is just about to start moving by itself (for static friction). When these points have been arrived at, then the ratio between the height and base of the plane gives the coefficient of friction. In

the diagram the height is 8 and the base 30. Therefore the coefficient is $\frac{8}{30}$ or ·26.

Angle of Friction. In the last experiment the angle at A which the board makes with the horizontal surface A C is called the *angle of friction*, the *angle of repose*, or the *limiting angle of resistance.* As in the previous case, it will be found that this angle is less when the board is so inclined as to permit of steady and uniform motion of W than when the weight is about to start moving. The angle of friction may be described, then, as the angle made by a plane with a horizontal surface at the moment when a body that is placed on the inclined plane begins to slide. The amount of frictional resistance of any substance may thus be considered and stated, either as regards its angle of friction or its coefficient. Generally, both these relations are stated. The following are interesting examples:

Substances	Coeff. of frict.	Ang. of frict. Deg.	Min.
Oak on elm, fibres parallel to motion..	·25	14	3
Wrought iron on brass ..	·17	9	39
Steel on cast iron	·20	11	19
Brass on cast iron	·22	12	25
Hard on soft limestone ..	·67	33	50

Referring again to **49**, the student who has any knowledge of trigonometry will see that the coefficient $\frac{8}{30}$ or $\frac{BC}{AC}$ is the tangent of the angle B A C. Thus, the angle at A can be measured and its tangent found by reference to a table of tangents. The coefficient of friction may therefore be stated in different ways, all having the same meaning. In **49** it is equivalent to $\frac{\text{height}}{\text{base}}$ or $\frac{\text{friction}}{\text{normal pressure}}$ or $\frac{\text{resistance}}{\text{normal pressure}}$ or tan A. This ratio is frequently represented by the Greek letter μ. If, then, F = frictional resistance, and R = normal pressure, $\frac{F}{R} = \mu$, and $F = \mu R$; that is, if R be known and multiplied by the coefficient of friction obtained from a table, the amount of friction between the two bodies may be determined. It will be noted that in the first experiment the coefficient of friction was stated as the ratio between the friction and the *weight*, and that now *normal pressure* is substituted for this term. By the normal, or perpendicular, pressure of a body is meant the amount of pressure acting *perpendicularly* to the surface on which it rests, and though this would be synonymous with the weight in **48**, it would not be so in **49**. The perpendicular pressure of a locomotive on a level track would be equal to its weight, but on a gradient the pressure acting perpendicularly to the rails would be less than the weight, and would continue to grow less as the slope increased.

Laws of Friction. Less than a century ago General Morin, of the French Army, discovered, after investigations lasting two or three years, certain fundamental laws governing friction. Though more delicate apparatus and more extensive experiments have shown that the universal application of these laws fails, yet they are sufficiently correct for all but extreme cases. The laws state that:

1. Friction is independent of the extent of the surfaces in contact.
2. The amount of friction is proportional to the pressure between the two surfaces in contact.
3. Friction is independent of the velocity with which one body moves over the other.

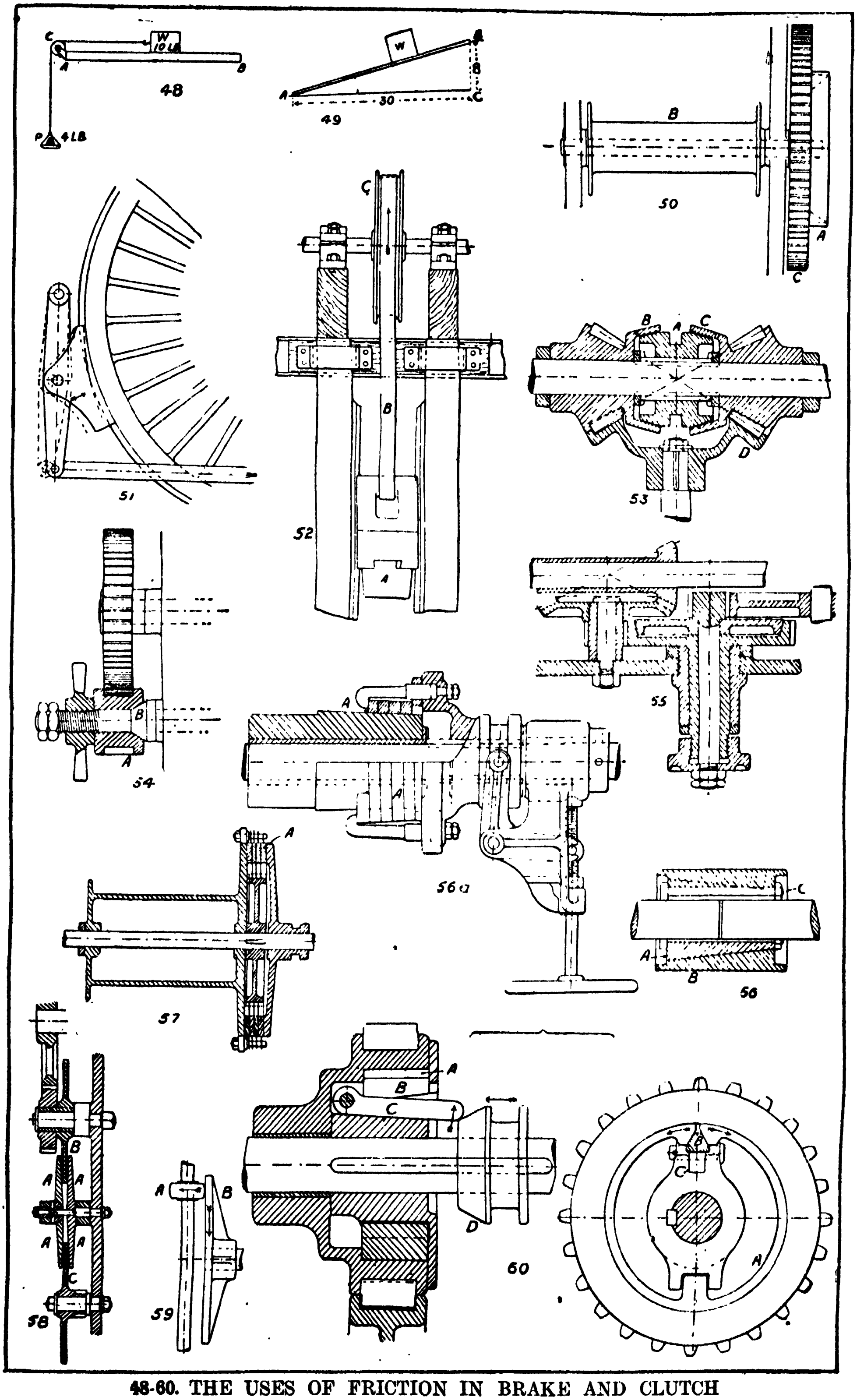
For ordinary pressures and velocities these laws are generally true, but are not correct for high velocities and extreme pressures. As velocity increases, the coefficient actually decreases, and vice versâ. Experiments with lubricated journals have shown that as the speed of revolution slowed down from 18 ft. per second to a stop the coefficient of friction gradually increased. Temperature is also an important factor. Several other laws or conditions have also been deduced from experiments.

4. Statical friction, or the friction of rest, is greater than kinetic friction, the friction of motion. This was proved in the experiments in the preceding paragraphs.
5. Statical friction is increased after the two surfaces have been in contact some little time.
6. Rolling friction is less than sliding friction.
7. In rolling friction the resistance is proportional to the weight, and inversely proportional to the radius of the wheel.
8. The work done in overcoming friction is transformed into heat or electricity.

Friction of Liquids. The laws just stated for solids do not apply to liquids. Investigations have so far failed to discover a coefficient of friction such as that for dry surfaces. Apparently, frictional resistance is proportional to the area of the surface of contact. At low velocities resistance is small, and probably = speed × area of surface × a coefficient, but at and above a certain critical speed the formation of counter currents increases resistance, so that speed in the above equation has to be squared. The resistance is largely independent of the material composing the solid body with which it is in contact, and it is also independent of the pressure to which the fluid is subjected.

The applications of the foregoing may divide themselves naturally under two heads—that in which the endeavour is made to utilise friction, and that where the object sought is to reduce it as far as possible. Each, therefore, involves entirely opposite sets of conditions, as each has an immense number of applications in practice.

Practical Applications: Brakes. Taking the first group named, we see friction utilised in brakes, in clutch connections, and in certain forms of gears for transmission of power. A common example of brake friction was illustrated in connection with the lever in the last chapter. The coefficient of friction, combined with the very large arc of contact between the brake strap and its band pulley, is so high that



48-60. THE USES OF FRICTION IN BRAKE AND CLUTCH

such brakes are capable of sustaining weights as high as eight to ten tons by their friction alone. This is regularly utilised in cranes, in which the reversal of the crane movements is avoided by "lowering with the brake." That means, of course, not that the brake does the lowering, but that the weight of the load is the agent, and the brake regulates the rate of, and checks, the descent at the right instant. Thus, **50** shows a brake (A), a drum (B), and barrel wheel (C), all on the same shaft. The load is hoisted on B by the wheel C, actuated by a pinion, but it is lowered by *braking* on A. In light mechanisms the same device is employed to bring rapidly rotating parts to rest in order to save time or to avoid danger. The most familiar example is the cycle brake.

Railway trains are brought to rest by the pressure of wooden or metallic brake-blocks pressing on a small portion of the circumference of the wheels [**51**]. But there is enormous pressure behind them, produced by vacuum or steam-pressure agency.

Belt-Hammers. Fig. **52** shows a friction device that may be seen in hundreds of smithies today—the drop-hammer. Only the upper portion is illustrated, as with that alone we are concerned. The tup, or hammer head (A), which delivers the blow on forgings or dies, is lifted by the frictional contact of the leather belt (B), around the smooth iron pulley wheel (C), rotated constantly by shafting. The workman puts on the friction by pulling at the free end of the belt and letting it go when the tup has been sufficiently raised. As long as he keeps his hand on the belt, the latter makes contact round an arc of 180° with the revolving pulley, and the latter lifts the belt and its tup by friction. The illustration shows the tup at its full height. On releasing his hand the tup falls instantly, and so he adjusts the height for such blows as the work requires—light or heavy, slow or rapid—by simply and instinctively varying the pull of the hand and thence the friction of the belt.

Clutches. An immense group of friction mechanisms are the clutches, by means of which rapid connection and disconnection is made between moving parts of mechanism. A whole line of shop-shafting driving to numerous machines can be set rotating by the movement through a lever or hand wheel of a comparatively tiny clutch, making connection between it and the source of power, engine or electric motor. It can be instantly disconnected by throwing out the clutch. In hoisting-machinery the same mechanism is frequently employed for throwing the different motions into and out of action.

The clutch arrangements are so designed that reversals of motion are effected without altering the direction of motion of the engines. The same design occurs over and over again in many groups of machines and machine tools. It comprises simply [**53**] a double-clutch (A), sliding and moved by means of a lever to right or left to engage with corresponding reverse clutches (B C), cast with bevel wheels, both of which engage with one crown wheel (D), so that the shaft rotating in one direction is made always to turn the crown wheel and its shaft in either one of two directions, according as the clutch is slid to right or left. These *cone clutches,* as they are termed, are used for both light and heavy machinery.

Cone friction is also employed on many machine tools for the purpose of starting and maintaining movements of parts. It is in the form of the cone clutch (friction feed) [**54** and **55**]. No great effort is required on the part of the attendant, but the simple turning of a cross handle [**54**] or a knob [**55**] puts it in and out of engagement. In **54** the pinion (A), normally running loosely on its shaft (B), is tightened thereon by pressure against the coned neck, and then drives, or is driven, by the wheel with which it is in mesh. In **55** the cones are of large size, drawn in by the knob and screw to traverse a lathe carriage through spur and bevel gears and rack (not shown). Fig. **56** represents a cone coupling for shafts. It is often made with two reverse cones. The cone is tightened round the shaft ends by friction grip obtained by drawing the split cone (A) along its sleeve (B), by the bolts (C), which are three in number.

Coil Clutches. A successful device for doing away with the rigidity of the common cone clutch is the coil clutch [**56**a]. It substitutes an elastic frictional medium (the coil A), which, being forced endwise, contracts and grips the inner cone. The coning is very small in amount. It is instant in action, and requires little power to hold it in place. It amounts practically to a split cone, to which, however, it is preferable. Pressure is brought to bear on the coil by any convenient means, as by the hand wheel, screw, and levers in the illustration.

But a friction clutch need not be coned. It may have flat faces, as in the Weston clutch [**57**] and modifications of it. Here discs of hard wood (A) as originally used are pressed into close frictional contact over their entire surfaces, and the grip is enormous. At present discs of steel and bronze have been substituted for wood, as they are more durable.

Sellers' Discs. Another form of friction drive used to a large extent for nearly twenty-five years past are the Sellers' discs [**58**]. Two discs (A A), having a slight capacity for adjustment towards and away from each other, embrace, or are released from contact with other discs (B and C) by a carefully graduated spring pressure acting on the globular boss seatings of A A. Motion is thus transmitted from the toothed gear adjacent, to B, through A A to C, by the simple frictional contact of the discs, and the lathe feed is thus actuated. This device, of course, also embodies provision, though not shown, for varying the rates of revolution between the driver (B) and the driven (C). A lever moves the centres of A A horizontally in relation to B and C, and thus produces engagement between the discs at the varying radii, with consequent varying rates of relative speed,

since the discs A A are capable of gripping B C at any radius. There is another common device—the bowl feed [59], in which a smooth-faced wheel (A) (the bowl) is driven by contact with the flat face of a disc (B) at varying rates. The variation is produced by altering the radius at which the bowl makes contact.

Expanding Clutches. In another common form of transmitting mechanism the friction is that of plain cylindrical surfaces. As these cannot be slid into and out of engagement like the coned form, the inner ring (A) [60] is divided in the radial direction, to render it elastic (an expanding clutch), and a wedge (B) is used to force it open sufficiently to make frictional contact with the outer casing. The wedge is actuated by a key (C) thrust along by a cone (D), also an example of wedge friction. Clutches of this general type in various modifications are used in hoisting-machinery, and in capstan lathes for the rapid throwing in and out of the back gears.

Expanding clutch rings are operated in various ways, one successful type, Heywood & Bridge's, being shown in **61**. The ring (A) in halves is thrust outwards to make frictional contact with the outer solid ring by sliding the clutch boss (B) on its shaft, and with it the toggle levers (C). The action is to turn screws of quick pitch on the pins (*a a*), which force the half rings outward away from each other simultaneously. The hand wheel (D) is the means by which the movements are effected, but this is a variable element, which differs in the numerous applications of the essential clutch mechanisms.

Friction Gears. A fair amount of gearing is made without teeth or cogs. Fig. **62** shows bevel wheels with smooth faces, and spur wheels are made similarly. They drive and are driven by frictional contact alone.

In another way, friction is often utilised for the transmission of power, in the wedge gearing [63]. Wheels transmit power by interlocking truncated wedge sections instead of by spur teeth. The advantage is that of very smooth running. In other words, the friction is all used for driving, and none is wasted, as in toothed gears. Instant connection and disconnection can be made. Unfortunately, this method of driving is not powerful enough for heavy loads, and its use is therefore restricted to light hoists.

Shafting Bearings. In the early part of this chapter the law was stated that friction was independent of the extent of surfaces in contact. Now, that fact is constantly receiving application in the bearings of shafting. Formerly, shaft bearings were short, from one and a quarter to one and a half times their diameter, and much trouble arose in consequence, due to their rapid wear and seizing. Now their length is made from twice to three times the diameter or more [64], with resulting lessening of friction per unit area, and greatly enhanced durability. Moreover, the higher the speeds at which machinery is run, the greater is the advantage of increased bearing length for the shafting. This is seen, among other examples, in the shaft bearings of blowers and fans, of circular saws, of moulding cutters, and of grinding machines, where it is common to find bearings from three to four times longer than their diameters.

Lessening of weight on bearings, with the object of reducing the intensity of friction, is studied. Thus, shafting of steel is substituted for that of iron, because steel may be of smaller diameter and of equal strength and stiffness with iron. Pulleys are made of steel instead of cast iron with the same object.

Belting. The friction of driving belts is the important factor in their application. Belts slip if the resistance of their work overcomes their friction. To increase friction as much as possible is the reason why horizontal are preferred to vertical drives, why a long drive is better than a short one, and why pulleys are selected, when possible, not greatly dissimilar in size. It is a question of amount of arc of contact. A horizontal drive is better than a vertical one, because the belt sags, and so lies better round its pulley on the driving side. In a vertical drive there is no sag. A long drive is better than a short one, because the sag is greater. Using pulleys reasonably alike in regard to size, the belt makes contact round, approximately, half the circumference, or 180° of arc, but with very large and very small pulleys it makes much less than 180° of arc round the small one, and the belt inevitably slips, an evil which is increased when the pulleys are near together, or with a vertical drive.

Out of this great fact of friction comes the important problem of the efficiency of machinery. In some cases half, or more than half, the power put into mechanism is lost in friction. If a machine sustains such loss, its efficiency is only 50 per cent., and, technically, that is its modulus. This is generally ascertained by means of a brake dynamometer, in which the absorption is measured directly.

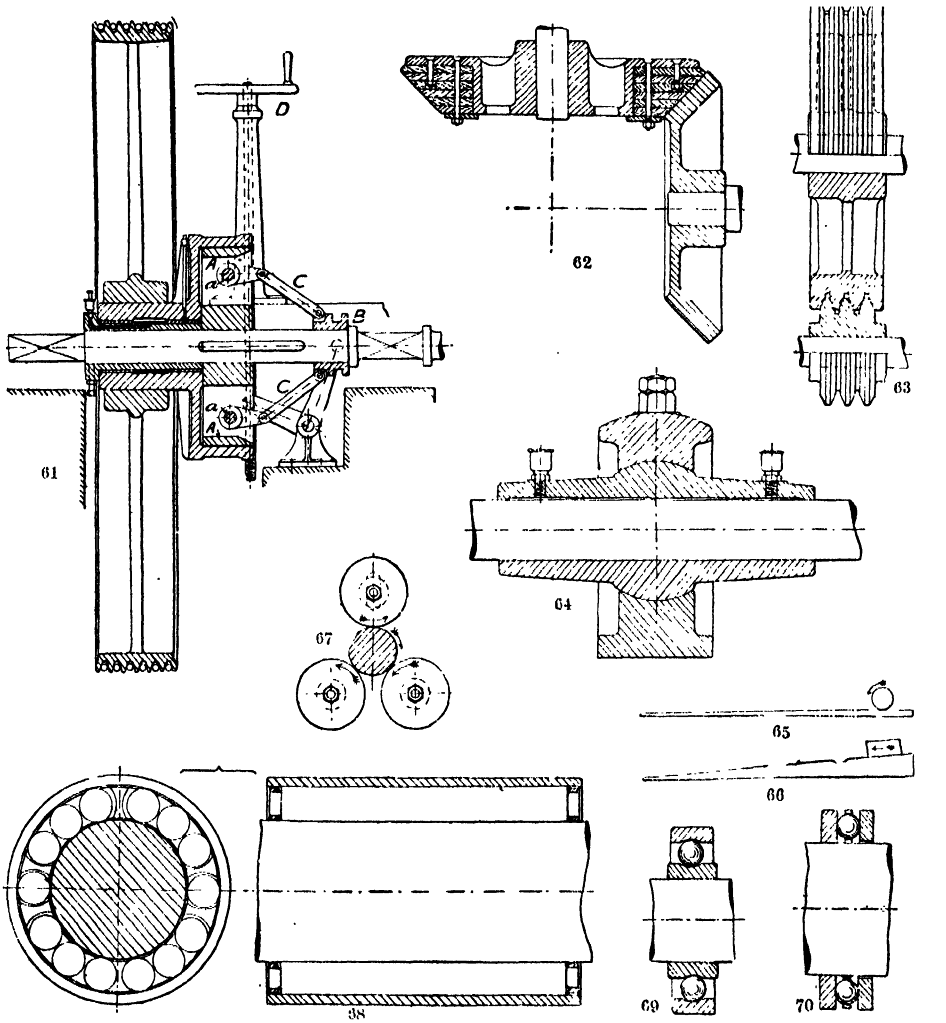
Rope Friction. The value of friction is seen in the coiling of a rope round a bar for the purpose of paying out or drawing in, applied in many laborious tasks. The labourer employs it in lowering heavy wine and beer casks into underground cellars, the woodman in felling trees. A crowbar is driven firmly into the ground at a considerable angle to prevent the rope from slipping off in the vertical direction. If a cask is being lowered, the rope is payed out in easy stages, and directly the weight begins to overhaul, the rope is pulled round to make a larger amount of contact with the bar, and so the cask descends safely.

In another way, rope friction is utilised in the warping-cones on wharves and dock sides and on shipboard. The coil of a rope twice or thrice round the body of a capstan is sufficient to bring the biggest vessels to rest, or to regulate their casting off from their moorings.

Rolling Friction. We now look briefly at the other aspect of friction, that in which the endeavour is made to get rid of it as an undesirable thing. With regard to the two

kinds of friction, that of sliding, which has been discussed, and rolling, the distinction is a most vital one. Imagine for a moment what would happen if a brake strap and its wheels were thoroughly greased or oiled with such a sensible thickness of lubricant that the brake and wheel could not come into actual contact. Each particle of grease or oil would be a tiny globule rolling between the surfaces and preventing contact. Substitute for oil an infinite number these is substituted for surface contact in the other class of mechanism is the frictionless ideal realised. Here difficulties of manufacturing come in, and also the difficulty of permanence, because in proportion as wear develops does the ideal become defeated. These things will be found treated under MACHINE DESIGN, but it is necessary to draw attention to them here.

The difference between rolling and sliding friction is illustrated in **65** and **66**. A ball or



61-70. EXAMPLES OF FRICTIONAL AND ANTI-FRICTION DEVICES

of minute steel balls—the effect would be the same, to prevent the surfaces from gripping at all. That would be rolling friction, substituted for the sliding friction of the band and wheel. Hence, if two surfaces can be separated by a rolling object, the friction which absorbs power is nearly eliminated. The ball and roller bearings, now so common, embody rolling friction, and are therefore to a great extent frictionless. Just in proportion as point or line contact in roller will run down a slope of 1 in 200 [**65**], but a block of polished metal [**66**], will require an angle of 1 in 14 at least to slide down.

Fig. **67** shows a common device in which the axle of a treadle lathe runs between three anti-friction rollers with great ease of movement. Fig. **68** is a roller bearing, and **69**, **70** ball bearings of two types, **69** being for a revolving shaft, the equivalent of a journal, and **70** one to take up end thrust. JOSEPH G. HORNER

Latin: The Roman Calendar. Subjunctive Mood. English: Adverbs. French: Verb and Plural of Nouns. Spanish.

LATIN

Continued from page 1175

By Gerald K. Hibbert, M.A.

SECTION I. GRAMMAR

Irregular Verbs: Second Conjugation

The most important exceptions to the regular formation of *-ui* and *-itum* are:

Perfect *-vi*, Supine *-tum*

deleo	delēre	delevi	deletum	*blot out*

(So also *Fleo* = weep, and *-pleo* = fill.)

Perfect *-ui*, Supine *-tum*.

doceo	docēre	docui	doctum	*teach*
misceo	miscēre	miscui	mistum	*mix*
teneo	tenēre	tenui	tentum	*hold*

Perfect *-si*, Supine *-tum*.

augeo	augēre	auxi	auctum	*increase*
torqueo	torquēre	torsi	tortum	*twist*
lugeo	lugēre	luxi	—	*mourn*

Perfect *-si*, Supine *-sum*.

mulceo	mulcēre	mulsi	mulsum	*soothe*

Similarly, *ardeo* (take fire), *rideo* (laugh), *suadeo* (advise), *maneo* (remain), *jubeo* (order, perf. jussi), *hæreo* (stick), *fulgeo* (glitter)

Perfect *reduplicates*, Supine *-sum*.

mordeo	-ēre	momordi	morsum	*bite*
pendeo	-ēre	pependi	pensum	*hang*
spondeo	-ēre	spopondi	sponsum	*pledge*
tondeo	-ēre	totondi	tonsum	*shear*

Perfect *-i*, Supine *-sum*.

prandeo,	-ēre	prandi	pransum	*dine*
sedeo,	-ēre	sedi	sessum	*sit*
video,	-ēre	vidi	visum	*see*

Perfect *-i*, Supine *-tum*.

caveo,	-ēre	cavi	cautum	*beware*
faveo,	-ēre	favi	fautum	*favour*
foveo,	-ēre	fovi	fotum	*cherish*
moveo,	-ēre	movi	motum	*move*
voveo,	-ēre	vovi	votum	*vow*

[Notice that most of our English nouns are derived from Supines—*e.g.*, torture, tonsure, vision, session, etc.]

Also three deponents:

fateor	fatēri	fassus	*confess*
misereor	miserēri	misertus or miseritus	*have pity on*
reor	rēri	ratus	*think*

The Roman Calendar

Names of the Roman months (all adjectives):

Januarius, a, um	Quintilis, e (*or* Julius)
Februarius, a, um	Sextilis, e (*or* Augustus)
Martius, a, um	September, bris, bre
Aprilis, e	October, bris, bre
Maius, a, um	November, bris, bre
Junius, a, um	December, bris, bre

[The year originally began with March; therefore, July was the fifth, September the seventh month, and so on. *Quintilis* and *Sextilis* were later called *Julius* and *Augustus* in honour of Julius Cæsar and the Emperor Augustus.]

Every Roman month had three chief days: *Kalendæ, -arum* (Calends); *Nonæ, -arum* (*Nones*), *Idūs, Iduum* (Ides): all three feminine. The Calends were always on the 1st: the Nones usually on the 5th, and the Ides usually on the 13th. But in March, May, July, and October, the Nones and Ides were two days later—*i.e.*, on the 7th and 15th respectively.

From these days the Romans counted *backwards*, the days between the 1st and the Nones being reckoned as so many days before the Nones; the days between Nones and Ides, as so many days before the Ides; and the remaining days of the month as so many days before the Calends of the next month.

1. When the date falls on one of the three chief days, the date is put in the abl., the month, of course, agreeing with the noun.

Jan. 1st *Kalendis Januariis.*
March 15th, *Idibus Martiis.*
Nov. 5th, *Nonis Novembribus.*

2. The day immediately preceding any of these three reckoning points was called "pridie" (*i.e.*, priore die), followed by the acc.

Jan. 31st. *Pridie Kalendas Februarias.*
Apl. 12th. *Pridie Idus Apriles.*
Oct. 6th. *Pridie Nonas Octobres.*

3. In any other date, we find out how many days it is before the next Calends, Nones, or Ides, (remembering to count in both the date in question *and* the Calends, etc.). Thus, Jan. 30th is the *third* day before the Februarian Calends, and would be in Latin *ante diem tertium Kalendas Februarias.*

Further examples:

Dec. 2nd. *Ante diem quartum Nonas Decembres.*
March 16th. *a.d. septimum decimum kalendas Apriles.*

These are usually written "a.d. IV. Non. Dec.," and "a.d. XVII. Kal. Ap.," and so with the others. The original signification of this expression seems to have been "before (on the fourth day) the Nones of December," the exact day being thrown in parenthetically, and attracted from abl. to acc. in consequence of following "ante."

4. In Leap Year, Feb. 24th (a.d. VI. Kal. Mart.) was reckoned twice, hence this day was called *dies bissextus*, and leap year itself, *annus bissextilis.*

SECTION II. COMPOSITION.

The Subjunctive Mood. This is one of the most difficult subjects in Latin. English usage gives no guidance, and, in fact, the subj. is as common in Latin as it is rare in English. In the following sentences, for example, the words in italics would be in the subj. mood in Latin: "It was so cold that the water *froze*" (consecutive after *ut*). "I asked why he *did* this?" (indirect question). "I fear that you *are* ill." "He said that the man who *did* this should die" (dependent verb in Oratio Obliqua). "There is no doubt that twice two *are* four." Roughly, we may say that the indicative indicates a fact, while the subj. expresses "something which we regard rather as a mere conception of the mind, as that which we purpose or wish to be a fact, or to which we refer as the result of another fact, or as stated on other authority than our own."

Usually, the subjunctive is used in certain classes of subordinate or *subjoined* clauses. But it is also used both in simple sentences and in the main clause of a compound sentence in the following cases:

1. To make a statement in a hesitating manner, sometimes called the potential mood. This is strictly a hypothetical subj. with the condition not formally expressed.

Hoc dicere ausim = I would dare to say this (if I were allowed).

Vix crediderim = I can hardly believe.

Hoc facias velim = I would have you do this ("ut" understood with "facias").

2. To ask a question, rhetorically, not for information; sometimes called dubitative questions. Usually a negative answer is expected.

Quis credat? = who would believe?

Quid ego facerem = what was I to do?

3. To express a wish or desire (optative or jussive), often with *utinam* (= would that!). Negative *ne*.

Utinam adjuvisset = would he had been present!

Di Carthaginem deleant = may the gods destroy Carthage.

Ne transieris Iberum = do not cross the Ebro. (In negative commands, use the perf. subj., not the imperative. Or else say *noli transire* = be unwilling to cross.)

Only in these classes of sentences is the subj. found in simple or principal sentences. In all the rest it is in subordinate sentences. Including those given above, there are eight main uses of the subj. mood:

1. Hypothetical: see No. 1 above. In these sentences the protasis (*i.e.*, the *if* clause of a conditional sentence) is suppressed.

2. Conditional—*e.g.*, *Si jussisses* (protasis), *fecissem* (apodosis) = if you had bidden, I should have done it. *Si adsis, facturus sum* = if you should be there, I mean to do it.

3. Optative, jussive, or concessive (see No. 3 above). "The imperative is the language of an absolute master; the subj. is a suggestion to an equal or superior."

In concessive sentences, a person rhetorically commands or supposes a change of what he knows or believes to be the fact.

4. Final, expressing purpose (negative *ne*).

(*a*) In adjectival sentences: *Dignus est qui vincat* = he is worthy to conquer. *Mitto qui dicat* = I send someone to say.

(*b*) In sentences introduced by *ut* (in order that), *ne, quo, quominus, quin*: *Ede ut vivas* = eat that you may live. *Non vixit ut ederet* = he did not live to eat.

(*c*) In sentences of time or condition, with *dum, dummodo, donec, priusquam*, etc. *Oderint dum metuant* = let them hate provided they fear.

5. Consecutive, expressing result; usually with *ut* = so that (negative, *ut non*): *Tam debilis sum ut non ambulare possim* = I am so feeble that I cannot walk. *Is sum qui illud faciam* = I am the man to do that.

6. Subj. of attendant circumstances: *Quæ quum ita sint, hoc dico* = under these circumstances (lit. since which things are so), I say this. *Peccavisse videor qui illud fecerim* = I seem to have sinned inasmuch as I have done that.

7. Subj. of reported statements, comprising sentences of definitions, reasons, and questions, which are given *not as the speaker's own*, but as someone else's.

Contrast "Laudat puerum quod *fuit* abstinens" (the reason alleged being given on the speaker's own authority) with "Laudat puerum quod *fuerit* abstinens" (the reason being a reported or assumed one, "He praises the boy, because he understands the boy to be abstemious").

8. Subj. because dependent on another subj. or infinitive. In all such sentences the subjunctive simply prevents the speaker from being supposed to be responsible for the statements, etc., reported, or to be giving them as independent assertions. To this head, of course, belongs the subj. in Oratio Obliqua. Examples:

(*a*) Depending on infinitive:
Dicit eos qui boni sint beatos esse (he says that those who are good are happy).

(*b*) Depending on another subjunctive:
Petit ut iis qui adfuerint credamus (he asks that we should believe those who were present). In such a case as this it is often said that *adfuerint* is *attracted* into the subj. by *credamus*.

TO BE TURNED INTO LATIN PROSE.

THE FUNERAL OF OLIVER CROMWELL.

BY ABRAHAM COWLEY.

It was the funeral-day of the late man who made himself to be called Protector. And though I bore but little affection, either to the memory of him, or to the trouble and folly of all public pageantry, yet I was forced by the importunity of my company to go along with them, and be a spectator of that solemnity, the expectation of which had been so great that it was said to have brought some very curious persons

(and no doubt singular virtuosos) as far as from the mount in Cornwall and from the Orcades. I found there had been much more cost bestowed, than either the dead man, or indeed death itself, could deserve. There was a mighty train of black assistants, among which, too, divers princes in the persons of their ambassadors (being infinitely afflicted for the loss of their brother) were pleased to attend; the hearse was magnificent, the idol crowned, and (not to mention all other ceremonies which are practised at royal interments, and therefore by no means could be omitted here) the vast multitude of spectators made up, as it uses to do, no small part of the spectacle itself.

LATIN VERSION OF THE ABOVE.

Dies erat quo inferebantur tumulo reliquiæ illius qui Protectoris nomen occupaverat. Me,[5] quamvis[6] neque[7] viri[11] memoriæ[10] neque[12] operosæ[13] publicarum[15] sollemnitatum[16] vanitatis[14] admodum[8] studiosum[9], perpulere[4] tamen[3] sociorum[2] preces[1] ut cum iis spectarem pompam illam, quæ tam cupide jamdudum fuerat expectata, ut nonnulli curiosiores, limatissimo nimirum ingenio homines, usque a monte apud Cornubios et ab Orcadibus insulis *visendi causâ** in urbem progressi essent. Intellexi multo plus in funus erogatum esse quam pro mortui meritis, immo pro mortis ipsius dignitate. Ingens pullatorum ordo, assistentibus etiam quibusdam legatis, qui regum personas fratrem summo studio desiderantium sustinerent: feretrum splendidissimum; coronata effigies; denique, ne omnia alia commemorem quæ, utpote in regum funeribus sollemnia, hic nullo modo omitti poterant, pars haud exigua spectaculi fuit, ut fit, vasta spectantium multitudo. (J. Conington.)

SECTION III. TRANSLATION.

A LETTER FROM CICERO TO HIS FRIEND ATTICUS. WRITTEN IN MARCH, B.C. 46:

Undecimo die postquam a te discesseram, hoc litterularum exaravi egrediens e villa ante lucem, atque eo die cogitabam in Anagnino, postero autem in Tusculano; ibi unum diem. V. Kalend. igitur ad constitutum; atque utinam continuo ad complexum meæ Tulliæ, ad osculum Atticæ possim currere! quod quidem ipsum scribe, quæso, ad me, ut, dum consisto in Tusculano, sciam quid garriat, sin rusticatur, quid scribat ad te, eique interea aut scribes salutem aut nuntiabis, itemque Piliæ. Et tamen, etsi continuo congressuri sumus, scribes ad me, si quid habebis.

Cum complicarem hanc epistolam, noctuabundus ad me venit cum epistola tua tabellarius, qua lecta de Atticæ febricula scilicet valde dolui. Reliqua, quæ exspectabam, ex tuis litteris cognovi omnia; sed quod scribis "igniculum matutinum gerontikon" (a Greek adjective, meaning "characteristic of an old man"), gerontikoteron (comparative) est memoriola vacillare: ego enim IV. Kal. Axio dederam, tibi III., Quinto, quo die venissem, id est prid. Kal. Hoc igitur habebis, novi nihil. Quid ergo opus erat epistola? Quid? cum coram sumus et garrimus quicquid in buccam? Est profecto quiddam "lesche" (gossip), quæ habet, etiam si nihil subest, collocutione ipsa suavitatem.

ENGLISH VERSION OF ABOVE.

Eleven days after leaving you, I am scrawling this bit of a note as I am starting from my country-house before dawn. I think of being at my villa at Anagnia to-day, and Tusculum to-morrow. Only one day there, so I shall turn up to time on the 28th, and, oh that I could run on at once to embrace my Tullia and give Attica a kiss! As to this very thing, do write me, I beg you, that while I am stopping at Tusculum I may know what she is prattling, or, if she is in the country, what she writes to you about. Meanwhile, either send or give her my love, and also to Pilia. Yet even though we shall meet immediately, write to me if you have anything to say.

P.S. When I was fastening up this letter, your courier reached me after travelling all night with your letter. I am very sorry, you may be sure, to hear, on reading it, about Attica's fever. All the other news I was waiting for I now know from your letter, but when you write that "to want a little fire in the morning is a sign of old age," I retort "it is a surer sign of old age that one's poor memory should falter." For I had intended to spend the 29th with Axius, the 30th with you, and the 31st with Quintus. So take that for yourself: you shall get no news. Then why write, you say? And, pray, what is the use of our chattering when we are together and saying whatever comes to our tongues? Surely there is something in a good gossip after all: for even if there is nothing in it, the very act of our talking together has a charm of its own.

* *Causâ* is an abl. = for the sake (or purpose) of; it follows the word which it governs. Here translate "for the purpose of seeing."

Continued

ENGLISH

Continued from page 1178

By Gerald K. Hibbert, M.A.

ADVERBS

Just as adjectives qualify nouns, so adverbs modify or limit verbs—as, "Agag came unto him *delicately*," "He gives *twice* who gives *quickly*." This usage has been extended, and adverbs can now modify adjectives and other adverbs in addition to verbs, as: "Too many cooks spoil the broth" (*too* modifying the adjective *many*), "He struck me *very* forcibly" (one adverb *very* modifying another, *forcibly*).

Adverbs, like adjectives (from which they are mostly formed), are usually classified according to their meaning: just as we divided

adjectives into Qualitative, Quantitative, and Relational, so we can divide adverbs. Thus:

1. ADVERBS OF QUALITY: *Well, ill, badly*, and all the adverbs in *-ly* derived from adjectives: *how, however, so, as, likewise*, etc. (sometimes called Adverbs of Manner).

2. ADVERBS OF QUANTITY:

a. Degree: *Very, nearly, almost, too, quite, enough, rather, much, more, most, little, less, least, only, but, just, even, any, the* (as in "*the* more *the* merrier"). Also the adverbs of Affirmation and Negation: *Not, no, nay, aye, yea, yes*.

b. Repetition of Time—as, *once, twice, thrice, often, seldom, always*, etc.

3. ADVERBS OF RELATION, showing

a. Time: *Now, then, after, before, soon, ago, instantly*, etc.

b. Place and Arrangement: *Firstly, secondly, thirdly, here, there, hither, thither, hence, thence, inside, outside, up, down*, etc.

c. Cause and Consequence: *Why, therefore, wherefore, accordingly, consequently*, etc.

It will be noticed that some of the words appearing in this list of adverbs have previously appeared as other parts of speech. *As*, for example, was included under Relative Pronouns; and *much, little, no, any*, were included under adjectives. To determine what part of speech a word is in a given sentence, we must consider the purpose it serves. Thus, "This is the same *as* that" (relative pronoun = "This is the same which that is"); "*As* he went out, he wept bitterly" (adverb denoting the time of the action). Again, "Give him *no* peace" (adjective), "This is *no* better than that" (adverb). Similarly, *much, little*, and *any* before comparatives are adverbs.

Formation of Adverbs. 1. From Adjectives. Most adverbs are formed by adding *-ly* to the corresponding adjective—*e.g., wild, wildly; cheerful, cheerfully*. The termination *-ly* (= like), is the Anglo-Saxon termination *-lic* (adjective), *licé* (adverb).

Adjectives ending in *y* preceded by a consonant change *y* into *i* before *ly*—*e.g., hearty, heartily; speedy, speedily*. *Shy* is an exception, making *shyly*, not *shily*. The adjective *gay*, which should strictly have *gayly* as its adverb, now usually makes *gaily*.

Adjectives ending in *-le* change the *e* into *y*—*e.g., noble, nobly; horrible, horribly*. When the adjective already ends in *-ly* the same form is generally used for the adverb—*e.g.*, the adverb of *godly* is usually *godly* ("We should live soberly, righteously and *godly* in this present world," Titus ii. 12), though *godlily* is sometimes used nowadays. So also *likely*: "a likely story" (adjective); "he will very *likely* come (adverb). Other adverbs derived from adjectives are *once, twice, thrice* (for *ones, twyes, thries*), *unawares, flatlong*. Some adjectives, in addition to those ending in *-ly*, are used as adverbs without any change of form—*e.g.*, "run *fast*," "stand *firm*," "strike *deep*," "*pretty* good," "Think not so *slight* of glory" (Milton).

2. From Nouns. *Needs* (as in "If I must needs glory"), *whiles, sideways, lengthways, straightways, noways*, are genitive cases of nouns. *Whilom* ("at whiles," "formerly") and *seldom* are dative cases plural of *hwil* (= space of time), and *seld* (= rare). Other adverbs derived from nouns are *headlong, sidelong, piecemeal* (mael = part), *inchmeal* ("All the infections that the sun sucks up . . . on Prosper fall, and make him by *inch-meal* a disease!"—*Tempest*), *limb-meal* ("O that I had her here to tear her *limb-meal*"—*Cymbeline*), *sometimes, always, perhaps, otherwise, midway*, etc. Many adverbs are compounds of the preposition *a* (meaning *on*) and a noun, as *afoot, abreast, aside, asleep;* while some are compounds of other prepositions with nouns, as *betimes* (by times), *besides, indeed*.

3. From Pronouns. *Thus, then, than; here, hither, hence; there, thither, thence; where, whither, whence; why, how* (for *whow*), and all the other adverbs formed from the Relative Pronouns, such as *wherefore, whereat, wherein, whereby*, etc.

These adverbs, that are derived from the Relative Pronouns (with the addition of *as* and *than*), are *Connective* or *Conjunctive* adverbs; that is, they retain the connective power which we have seen belong to Relative Pronouns. A Connective adverb introduces a subordinate clause, and modifies the predicate of this clause. There is always an antecedent expressed or understood in the principal sentence: thus, "He fell full length, *whereat* the bystanders laughed immoderately" (*whereat* modifies *laughed;* we know it to be a Connective or Relative adverb because we could substitute "and thereat" for it). Again, "And now, too soon for us, the circling hours This dreaded time have compassed, *wherein* we Must bide the stroke of that long-threatened wound" (*Paradise Regained*).

Here we could substitute "and therein" for "wherein." The antecedent here is *time;* in the previous illustration the antecedent is "the fact of his falling." These Connective Adverbs must be carefully distinguished from Conjunctions.

Negative Adverbs. *Not* is shortened from *nought* or *naught*, and literally means "in no whit, in no degree." In Old English, *ne* (= *not*) is employed before the verb, and a form corresponding to *naught* after the verb, the two negatives strengthening each other; thus, in Robert of Gloucester's *Chronicle* (A.D. 1298) we find "*Ne* be thou naught so sturne" ("Be thou not in any way so stern"), and in Chaucer's *Canterbury Tales* we have

"There was also a Doctour of Physik,
In all the world *ne* was there *none* him like."

Also "Nor hath not one spirit to command" (*Tempest*).

In modern English, two negatives, so far from strengthening each other, neutralise each other,

although Matthew Arnold follows the old usage when he writes:

> "No easier nor no quicker pass'd
> The impracticable hours."

No and *nay* are from *na*, meaning *never*, while *aye* (affirmative) is from *a*, meaning *ever* (cf. *for aye*, meaning *for ever*. "This world is not for aye," *Hamlet*). *Yes* is from Anglo-Saxon *gese* or *yea*, yea, and *sy* (subjunctive mood, meaning "let it be").

Comparison of Adverbs. Most adverbs are compared by prefixing *more* and *most* to the positive, as *willingly, more willingly, most willingly.* But a few, and especially those which have the same form as the corresponding adjectives, are formed by the suffixes *-er*, *-est*; as:

Positive.	*Comparative.*	*Superlative.*
firm	firmer	firmest
fast	faster	fastest
soon	sooner	soonest
early	earlier	earliest

The following are irregular (see "Comparison of Adjectives" on page 395):

Positive.	*Comparative.*	*Superlative.*
well	better	best
badly, evilly, *or* ill	worse	worst
much	more	most
far	farther	farthest
forth	further	furthest
nigh *or* near	nearer	nearest / next
late	later / latter	latest / last
[rathe, *adjective*]	rather	—
—	ere	erst
lief	liefer	—

Rathe meant *quick, early*; *Rather*, therefore, means *quicker, earlier, sooner*. Thus, in *Piers the Plowman*, by William Langland (A.D. 1362), we find it used as an adverb:

> "Let not thi luft hond, late ne *rathe*,
> Beo war what thi right hond worcheth or deleth."

("Let not thy left hand, late nor early, be aware of what thy right hand worketh or distributeth.")

Also Milton in *Lycidas* has "the *rathe* primrose" (adjective). Rath is still used in the Sussex dialect, as "Happens you were up *rath* this morning" (adverb), "She is given to taking long rambles in the *rath* morning" (adjective).

Ere is the Anglo-Saxon *aer*, a comparative adverb of time. It is now used mainly as a conjunction. *Erst* means *formerly*, and is shortened from *aerest*.

Position of Adverbs. Adverbs are usually placed as near as possible to the words they modify, and generally *before* an adjective or other adverb, and *after* a verb. For emphasis, however, an adverb may precede the verb, and even stand as the first word of a sentence. The poets take liberties with adverbs, and place them as they like; thus, Milton writes: "The rest . . . . will far be found unworthy to compare with Sion's songs," instead of "far unworthy." This usage should not be imitated.

Continued

FRENCH

By Louis A. Barbé, B.A.

THE VERB

First Conjugation

The first conjugation consists of verbs of which the infinitive ends in *er*: *aimer*, to love, like; *donner*, to give; *garder*, to keep; *marcher*, to walk; *regarder*, to look; *représenter*, to represent.

The endings of all regular verbs of the first conjugation in the present indicative are: *e, es, e, ons, ez, ent*:

Affirmatively.

j'aime, I love
tu aimes, thou lovest
il aime, he loves
elle aime, she loves
nous aimons, we love
vous aimez, you love
ils aiment, they (m.) love
elles aiment, they (f.) love

Negatively.

je ne donne pas, I do not give
tu ne donnes pas, thou dost not give
il ne donne pas, he does not give
elle ne donne pas, she does not give
nous ne donnons pas, we do not give
vous ne donnez pas, you do not give
ils ne donnent pas, they (m.) do not give
elles ne donnent pas, they (f.) do not give

The syllable *ent* of the third person plural is mute.

EXERCISE VI.

Vocabulary.

un appétit, an appetite
un arbre, a tree
une aubépine, a hawthorn
un aubour, a laburnum
en automne, in autumn
la baie, the berry
le bâtiment, the building
le bord, the edge
le bout, the end
la brebis, the sheep
la campagne, the country
la cerise, the cherry
le cerisier, the cherry tree
la charrette the cart
le chaume, the thatch
le cheval, the horse
le clocher, the steeple
la colline, the hill
le contrevent, the shutter
la cour, the courtyard
la couverture, the cover
le cuisinier the cook
une eau, a water
une écurie, a stable (for horses)
une église, a church
en été, in summer
une étable, a stable (for cattle)

un exercice, an exercise
la faim, the hunger
la ferme, the farm
le festin, the feast
la feuille, the leaf
la fille, the girl
le fruit, the fruit
le facteur, the postman
la girouette, the vane
la gravure, the engraving
l'herbe (f.), the grass
en hiver, in winter
un homme, a man
le houx, the holly
le jardin, the garden
la jument, the mare
la laine, the wool
le lait, the milk
le laurier, the laurel-tree
la lettre, the letter
le lilas, the lilac
le magasin, the shop
le mets, the dish (food)
la neige, the snow
le pré, the meadow
la personne, the person
la poire, the pear
le poirier, the pear-tree
la pomme, the apple
le pommier, the apple-tree
le pont, the bridge
au printemps, in spring
le repas, the meal
la rue, the street
le réverbère, the street-lamp
la rivière, the river
le sac, the bag
le sorbier, the mountain-ash
la terre, the ground
le trottoir, the footpath
la vache, the cow
le verger, the orchard
la ville, the town
une yeuse, an evergreen oak
la voiture, the carriage
agréable, pleasant
beau, fine, beautiful
blanc, white
bon, good
clair, clear
doux, sweet
frais, fresh
fin, delicate, dainty
grand, big, tall
gai, cheery
haut, high
joli, pretty
large, broad
luisant, glossy
mûr, ripe
nouveau, new
nu, bare
piquant, prickly
plein, full
propre, clean
rouge, red
savoureux, luscious
triste, dreary, sad
utile, useful
vert, green
vieux, old
garder, to keep
je prends, I take
je vais, I go
je vois, I see
à, at, to
au delà de, beyond
de, of, from
derrière, behind
devant, before, in front of
par, through, by
parmi, amongst
aussi, also
plusieurs, several
toujours, always
quand, when

I look through the window. In front of the window there is a large garden. In the garden there are some trees. Amongst the trees there are a fine laburnum, a pretty lilac, a hawthorn, an evergreen oak, and a mountain-ash. There are also some laurel-trees. They are always green. The evergreen-oak also is always green. In autumn the mountain-ash has berries. They are red. In winter the holly has berries also. The leaves of the holly are glossy and prickly. In spring the holly and the mountain-ash have no berries. Beyond the trees I see a bridge. Under the bridge there is a small river. The water of the river is fresh and clear. Beyond the bridge there is a broad street. The street has two footpaths. At the edge of the footpaths there are some street-lamps. In the street there are several persons. They walk on the footpath. One of the persons is a postman. He has a bag full of letters. There are also a carriage and a horse. There is no cart. At the end of the street there is a church. It has a fine steeple. The steeple is high. It has a vane. The church is not old, it is new. From the window I go to the table. I take a little book. The cover of the book is blue. In the book there are some pretty engravings. One of the engravings represents a farm. The farm is in a large courtyard. It has a stable-for-horses and a stable-for-cattle. In the stable-for-cattle there are cows. The cow gives milk. The stable is the horses' house. The stable is not a large building. In the stable there are a young horse and an old mare. Near the farm there is a meadow. In the meadow there are sheep. A little girl keeps the sheep. The sheep gives wool. The wool of the sheep is useful to (the) man. Behind the farm there is an orchard. In the orchard there are apple-trees, pear-trees, and cherry-trees. (The) apples are the fruit of the apple-tree. (The) apples are good when they are ripe. (The) cherries are the fruit of the cherry-tree. They are sweet. (The) pears are luscious. I like the country. In summer I go to the country. I have a little house on a pleasant hill. It is white. The shutters are green. The roof is of thatch. It is clean and cheery. In (at) the country (the) exercise gives a new appetite. (The) hunger is a good cook (f.). The dishes are dainty. The meals are feasts. In winter I do not like the country. It is bare and dreary. The trees have no leaves. There is snow on the ground. In winter I like the town.

FORMATION OF THE PLURAL

Nouns and Adjectives

Nouns and adjectives form their plural in the same way, and according to the following rules:

1. To form the plural of nouns and adjectives, add *s* to the singular: *le livre*, the book, *les livres*, the books; *un enfant poli*, a polite child, *des enfants polis*, polite children; *la belle orange*, the fine orange, *les belles oranges*, the fine oranges.

2. When the singular ends in *s*, *x*, *z*, there is no change for the plural: *le fils*, the son, *les fils*; *la voix*, the voice, *les voix*; *le nez*, the nose, *les nez*; *un fils doux et soumis*, a gentle and dutiful son, *des fils doux et soumis*.

3. When the singular ends in *au*, *eau*, *eu*, the plural is formed by adding *x*: *le noyau*, stone (of fruit), *les noyaux*; *le bateau*, boat, *les bateaux*; *le feu*, fire, *les feux*; *un livre hébreu*, a Hebrew book, *des livres hébreux*. The noun *landau*, landau, and the adjectives *bleu*, blue, and *feu*, late (deceased), take *s* for the plural: *un landau bleu*, a blue landau, *des landaus bleus*; *le feu prince*, the late prince, *les feus princes*.

4. The following seven nouns in *ou* also take *x* for the plural: *bijou*, jewel; *caillou*, pebble; *chou*, cabbage; *genou*, knee; *hibou*, owl; *joujou*, toy; *pou*, louse. All other nouns in *ou*, and all adjectives in *ou* take *s*: *le clou*, nail, *les clous*; *le verrou*, bolt, *les verrous*; *un corps mou*, a soft body, *des corps mous*; *un prix fou*, an extravagant price, *des prix fous*.

5. When the singular ends in *al*, the plural is formed by changing *al* into *aux*: *le mal*, evil, ache, *les maux*; *le cheval*, horse, *les chevaux*;

le tribunal, les tribunaux; un conseil amical, friendly advice, *des conseils amicaux; l'instinct brutal,* brutal instinct, *les instincts brutaux.* Exceptions: The following (*a*) nouns and (*b*) adjectives take *s* for the plural: (*a*) *aval,* endorsement; *bal,* ball (party); *cal,* callosity; *carnaval,* carnival; *chacal,* jackal; *nopal,* nopal (Indian fig); *pal,* pale; *régal,* treat; (*b*) *fatal, final, filial, glacial, jovial, magistral* (masterly), *matinal* (matutinal), *mental, natal, naval, pénal, sentimental.*

6. The nouns in *ail* in common use are nearly equally divided between (*a*) those that form their plural by changing *ail* into *aux,* and (*b*) those that only add *s.*

(*a*) *Bail,* lease, *baux; corail,* coral, *coraux; émail,* enamel, *émaux; soupirail,* air-hole, *soupiraux; vantail,* leaf of folding-door, *vantaux; vitrail,* stained-glass window, *vitraux.*

(*b*) *Camail,* bishop's cape, *camails; détail,* detail, *détails; éventail,* fan, *éventails; gouvernail,* rudder, *gouvernails; poitrail,* chest (of horses), *poitrails; portail,* porch, *portails.*

7. The plural of some nouns offers peculiarities and irregularities: (*a*) *aïeul* in the singular means grandfather, and has *aïeuls* for its plural: *il a deux aïeuls,* he has two grandfathers. It has a second plural form with the meaning of ancestors: *il a des aïeux nobles,* he has noble ancestors. In this second sense the word is never used in the singular. It is customary to say "one of the ancestors," instead of "an ancestor."

(*b*) *Ail,* garlic, has two plurals, *ails* and *aulx.* Botanists prefer the regular form: *la famille des ails,* the garlic family. The irregular form is more commonly used: *il y a des aulx cultivés et des aulx sauvages,* there are cultivated garlic plants and wild garlic plants.

(*c*) *Ciel,* sky, heavens, usually has the plural *cieux: la voûte des cieux,* the heavenly vault. When *ciel* is used (*a*) to indicate the skies of pictures, (*b*) as the equivalent of climate, or (*c*) in a figurative sense, its plural is *ciels:* (*a*) *il peint de beaux ciels,* he paints beautiful skies; (*b*) *la Grèce et l'Italie sont situées sous de beaux ciels,* Greece and Italy are situated beneath beautiful skies; (*c*) *des ciels de lit,* bed canopies.

(*d*) *Œil,* eye, usually has the plural *yeux: elle a de beaux yeux,* she has beautiful eyes. In compound words in which it is used figuratively, it forms its plural regularly: *des œils-de-bœuf,* bullseye windows; *des œils-de-chat,* catseyes (precious stones).

(*e*) *Travail,* when it means work, has the plural *travaux: des travaux manuels,* manual labour. When used in the sense (*a*) of a brake for shoeing vicious horses, or (*b*) of official reports to the head of a department, it forms its plural regularly.

(*f*) *Bétail* has no plural, and *bestiaux* has no singular. Both mean cattle, and may be used to supplement each other.

8. Some nouns have one meaning in the singular and two meanings in the plural. The most usual of these are: *une arme,* weapon, *des armes,* weapons, and coat of arms; *un arrêt,* stoppage, *des arrêts,* stoppages, and arrests; *le ciseau,* chisel, *les ciseaux,* chisels and scissors; *la défense,* defence, *les défenses,* defences, and tusks; *le fer,* iron, *les fers,* different kinds of iron, and fetters; *la lunette,* telescope, *les lunettes,* telescopes, and spectacles.

9. Some nouns are used only in the plural. The most common of them are:

les agrès (m.), rigging	*frais* (m.), expenses
les alentours (m.), surroundings	*funérailles* (f.), funeral
les broussailles (f.), brushwood	*immondices* (f.), filth
les décombres (m.), rubbish	*matériaux* (m.), material
les dépens (m.), costs	*mœurs* (f.), morals, manners
environs (m.), environs	*obsèques* (f.), obsequies
fiançailles (f.), betrothal	*ténèbres* (f.), darkness
	vivres (m.), provisions

Exercise VII.

1. There are some beautiful books.
2. The children are polite.
3. You have some fine oranges.
4. Boats have rudders.
5. Peaches (*pêche*) and apricots have stones.
6. We have given prizes (*prix*) to the pupils (*élève*).
7. The doors have no bolts.
8. The children's toys are broken (*cassé*).
9. The princess's jewels have cost (*coûté*) exorbitant prices.
10. There are some cabbages in the garden.
11. The shepherds (*berger*) tend (*gardent*) the flocks (*troupeau*).
12. Horses are useful animals.
13. There are no jackals in England (*Angleterre*).
14. The churches (*église*) have beautiful stained-glass windows.
15. The generals have noble ancestors.
16. We have no need of fans.
17. The little girls have blue eyes (the eyes blue).
18. They have given several (*plusieurs*) balls.
19. The vault of the heavens is strewn with (*parsemée de*) stars (*étoile*).
20. The works of men are perishable (*périssable*).

Key to Exercise V. (page 920)

1. Il y a quatre saisons: le printemps, l'été l'automne, et l'hiver. 2. Le printemps est la première saison de l'année. 3. L'hiver n'est pas la saison des fleurs. 4. En été il n'y a pas de neige. 5. Le mois de Décembre est un des mois de l'hiver. 6. La pomme est le fruit du pommier. 7. Le rosier n'a pas des fruits. 8. Le chêne est un arbre, la bruyère est un arbrisseau. 9. Il y a un hêtre et une aubépine derrière la maison. 10. Il a une prune, elle a un abricot, et nous avons des cerises. 11. Il y a un oiseau dans la cage. 12. Les enfants sont sur la plage. 13. Le frère et la sœur ont la rougeole. 14. J'ai une migraine. 15. Le mensonge est un vice. 16. La sentinelle n'est pas une recrue. 17. Il y a une gravure sur la première page du livre. 18. J'écris avec la craie. 19. Le marin et le mousse aiment la mer. 20. La fin de la leçon.

Continued

Continued from page 1036

Present Participle. The infinitives of all verbs end either in *ar* (first conjugation), *er*, or *ir* (second and third conjugations). The present participle or gerund of the first conjugation is formed by changing the termination *ar* of the infinitive into *ando;* and those of the second and third conjugations by changing the termination *er, ir* of the corresponding infinitives into *iendo.* The present participle describes an action in a state of progression.—*hablar*, to speak; *hablando*, speaking; *comer*, to eat; *comiendo*, eating; *abrir*, to open; *abriendo*, opening. "To be" in front of a present participle is always translated by *estar.*

EXERCISE XI

To sing	*Cantar*	To thunder	*Tronar*
To walk	*Pasear*	To sign	*Firmar*
To buy	*Comprar*	To drink	*Beber*
To sell	*Vender*	To run	*Correr*
To rain	*Llover*	To learn	*Aprender*
To live	*Vivir*	To print	*Imprimir*
Document	*Documento*	Glass	*Vaso*
Milk	*Leche*	Sugar	*Azúcar*

1. She is singing. 2. They are walking. 3. We are running. 4. They are selling. 5. I am learning Spanish. 6. It is thundering 7. Are you (sing.) writing a letter to my friend? 8. Where are they living now ? 9. He is opening the door. 10. We are signing the document. 11. She is buying a new hat. 12. I am drinking a glass of milk. 13. It is raining. 14. They are printing a book.

Past Participle. The past participle of all regular verbs is formed from the infinitive by changing its terminations *ar, er, ir* into *ado* for the first conjugation, and into *ido* for the second and third conjugations.—*hablar, hablado*, spoken; *comer, comido*, eaten; *recibir, recibido*, received.

EXERCISE XII

To change	*Cambiar*	To offer	*Ofrecer*
To arrange	*Arreglar*	To grant	*Conceder*
To reject	*Rechazar*	To read	*Leer*
To ask	*Preguntar*	To lose	*Perder*
To ask for	*Pedir*	To go	*Ir*
Money	*Dinero*	To come	*Venir*
Offer	*Oferta*	Name	*Nombre*
Year	*Año*	Goods	*Géneros*
New	*Nuevo*	Customer	*Cliente*
Report	*Informe*	Bank	*Banco*
Docks	*Muelle*	Partner	*Socio*
Bonus	*Bonificación*	Particulars	*Detalles*
Messenger	*Mensajero*	Manufacturer	*Fabricante*
Morning	*Mañana*		

1. She has changed her money. 2. They (fem.) have arranged the papers. 3. His partner has rejected the offer. 4. Have you asked his name? 5. We have not offered new goods this year. 6. The manufacturers have granted a bonus to their customers. 7. I have not read the report yet. 8. My friend has lost his situation. 9. Have you (pl.) received the drafts? 10. We (fem.) have asked for particulars of the offer. 11. The clerk has gone to the post office. 12. Your messenger has come late this morning.

The Past Definite. The past definite is very frequently translated by the compound tense.—*¿ ha visto Vd su libro ?* did you see his book ? *he escrito una carta esta mañana ;* I wrote a letter this morning; *ha ido al casino ante de las* (before of the) *doce ;* he went to the club before 12 o'clock.

The personal object of a verb is always preceded in Spanish by the preposition *á.*—*he encontrado á su primo* ; I have met his cousin.

Interrogative and Relative Personal Pronouns. Relative pronouns are those which relate to a previous word or phrase. When these pronouns are used in asking a question they are called interrogative.

	Singular	Plural
Who	*quien*	*quienes*
whose	*cuyo*	*cuyos*
of, to, for, etc., whom	*de, á, para,* etc., *quien*	*de, á, para,* etc., *quienes.*

These words have no gender except *cuyo*, which takes the gender and number of the following noun.—*el autor cuyos libros he leido ;* the author whose books I have read. The relative pronoun must be always expressed in Spanish, although in English it is sometimes omitted. When "whom" does not follow a preposition, it may be rendered by *que.*—*el empleado que han despedido ;* the clerk (whom) they have dismissed.

The relative pronoun "who" is generally translated by *que,*—*el hombre que ha abierto la puerta ;* the man who opened the door. But "who" after the verb "to be" is usually rendered by *quien, quienes.*—*¿ es Vd quien ha enviado esta factura ?* is it you who has sent this invoice ? In phrases of this kind, "who" may also be translated by *el que, la que, los que, las que*, according to the gender and number of the subject of the sentence.—*yo soy el que ha dicho eso*, it is I who said that.

EXERCISE XIII

Theatre	*Teatro*	Telegram	*Telegrama*
It is I	*Soy yo*	Staircase	*Escalera*
Last night	*Anoche*	To knock	*Llamar*
To dine	*Cenar*	Downstairs	*Abajo*
To bring	*Traer*	Merchant	*Comerciante*
There	*Ahí*	To smoke	*Fumar*
Bank-note	*Billete de banco*	The whole morning	*Toda la mañana*

1. Who is there ? 2. It is I. 3. Who (pl.) went to the theatre last night ? 4. That is the merchant whose wire we received this morning. 5. Whose pencil is this (translate "of whom is this pencil") ? 6. To whom have you spoken in the staircase ? 7. For whom is that invoice ? 8. The man (whom) we have seen in the street is the manager of the office. 9. It is we who changed the bank-note. 10. It is you who knocked at the door ? 11. No; the man who knocked is downstairs. 12. With whom have you dined ? 13. I have not dined yet ; I have not had time. I have been very busy the whole morning. 14. Who is smoking in the drawing-room ? 15. The men who have brought the trunks.

Other Interrogative and Relative Pronouns. The other interrogative and relative pronouns are as follow:

	Singular	Plural
Which one ?	*¿ Cuál ?*	*¿ cuales ?*
Of which	*cuyo*	*cuyos*
To, for, etc., which	*á, para,* etc., *cual*	*á, para,* etc., *cuales.*
that	*que*	
what	*qué*	

EXAMPLES: *¿ Cuál es su libro ?* which is his book ? *la carta cuya copia ha desaparecido,* the letter the copy of which has disappeared; *la letra que he firmado,* the draft that I have signed. *¿ Qué billete ?* what ticket ?

The interrogative adjective "which" may be translated by *qué.—¿ qué palabra ?* which word ? The relative pronoun "which" is nearly always translated by *que,* except when it is dubitative. —*los géneros que Vd ha enviado,* the goods which you have sent; *no se cual es el mejor,* I do not know which is the best.

It must be noted that the subject of a Spanish relative sentence is usually placed after the verb. —*las noticias que ha traido el vapor,* the news which the steamer has brought. Whenever "which" relates to a full previous sentence, it is rendered in Spanish by *lo que* or *lo cual.* —*ha dicho que han llegado, lo cual no es verdad,* he has said that they have arrived, which is not true. "Who" and "which" (relative) may sometimes be translated by *el cual, la cual, los cuales, las cuales.—hemos comprado dos máquinas de escribir, las cuales* (or *que*) *están arriba,* we have bought two typewriters, which are upstairs; *he encontrado á su agente, el cual está en Londres,* I have met his agent, who is in London.

The words "what a !" and "how !" in exclamations, are translated by *¡ Qué !* — *¡ Qué lástima !* What a pity ! *¡ Qué extraño !* How strange !

EXERCISE XIV

Dictionary	*Diccionario*	Box	*Caja*
To telegraph	*Telegrafiar*	Lovely	*Lindo*
Strange	*Extraño*	Cashier	*Cajero*
To communicate	*Comunicar*	To check	*Comprobar*
		To order	*Pedir*
At once	*En el acto*	Answer	*Respuesta*

1. Which dictionary. 2. Which drafts ? 3. He sent two signed cheques which I have no received. 4. Which one have you brought ? 5. I have written the report I promised (translate, "which I have promised"). 6. I do not know which ones he has. 7. He has not wired yet, which is very strange. 8. We have ordered ten boxes, which have not arrived yet. 9. I have communicated the news to the cashier, who has checked the accounts at once. 10. What an answer! 11. How lovely !

KEY TO EXERCISE VII

1. ¿ Son Vds comerciantes de Madrid ? 2. No; yo soy abogado y mis amigos son médicos. 3. ¿ Está el vapor en la bahía ? 4. No, señor; todavía no; 5. ¿ Es ese caballero su padre (de Vd)? 6. No; es mi tío. 7. ¿ Estamos cerca de su fábrica ? 8. No; está muy lejos de aquí. 9. ¿ Dondo están mis baules ? 10. Están en el andén número cinco. 11. ¿ Está Vd mareado ? 12 No, gracias; estoy muy bien. 13. ¿ Está la puerta del (de el) comedor en el jardín ? 14. No; ahora está en la estación, á la derecha de la taquilla. 15. ¿ Son Vds extranjeros ? 16. Si, señor; somos españoles. 17. ¿ Donde estamos (nosotras) ahora ? 18. Vds están en la aduana. 19. ¿ Está el empleado en la oficina ? 20. No, señora; está á bordo del vapor de Valparaíso.

KEY TO EXERCISE VIII

1. El salario de un empleado. 2. Los ojos de los caballos. 3. El pan del mendigo está duro. 4. El árbol de mi vecino es demasiado alto. 5. El alma del hombre es inmortal. 6. La harina americana es muy buena. 7. Las calles son largas y estrechas. 8. Las alas de los pájaros son cortas y blancas. 9. El ancla del barco alemán es demasiado pequeña. 10. Las joyas de su hermana (de ella) son hermosas. 11. El pan francés es bueno. 12. Mi padre y mi madre están bien. 13. La casa y el jardín son grandes. 14. Su amiga (de V.) italiana es muy cortés y alegre. 15. La pronunciación inglesa es difícil. 16. Cualquier papel blanco. 17. Mal tiempo.

KEY TO EXERCISE IX

1. Este libro es más grande que aquel. 2. ¿ Es esa la estación ? 3. Ese bastón es de mi hermano. 4. Estos periódicos son españoles. 5. No comprendo eso. 6. No es eso. 7. Estos cigarros son mejores que aquellos. 8. Mi hermano no es tan alto como V. 9. Esta lección no es tan difícil. 10. Esas casas están más cerca que la fábrica.

KEY TO EXERCISE X

1. Tengo un buen espejo en mi cuarto. 2. Hemos dejado nuestras maletas en el tren. 3. ¿ Tiene V. sed ? 4. ¿ Por qué no ha ido V. á Londres ? 5. ¿ Han encontrado su traje azul (de ella) ? 6. ¿ Tiene (ella) bastante azúcar ? 7. Nosotros no tenemos teléfono en la oficina. 8. He perdido su dirección (de V.). 9. El tiene un buen destino en Méjico. 10. ¿ Han venido (ellos) ? 11. ¿ Tengo que firmar ese papel ? 12. V. tiene que escribir lo antes posible.

READING EXERCISE

Shakespeare escribió para un pueblo que empezaba á ser grande, que iba á extender su imperio, á mejorar su civilización castiza y propia, á difundirla y á hacerla valer por todas las regiones del mundo. Como escribió para el pueblo, escribió inspirado y lleno de los pensamientos y sentimientos del pueblo, y su mente y sus obras están henchidas de lo porvenir; contienen en gérmen todo el espíritu de Inglaterra en el día.

TRANSLATION OF THE ABOVE PASSAGE

Shakespeare wrote for a nation beginning to be great, about to extend its empire, improve its individual and racial civilisation, and diffuse and make it felt throughout all the regions of the earth. Writing for the people, he was inspired by, and full of, the thoughts and feelings of the people, and his mind and works are big with the future; they contain the germ of the spirit of England today.

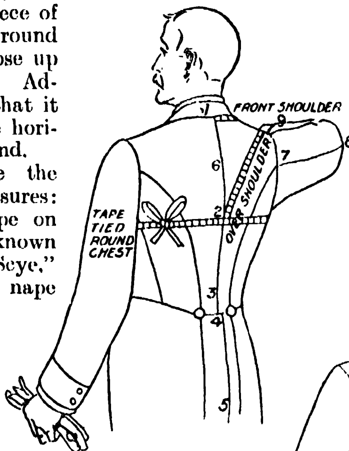
Continued

Drafting Lounge, Morning, and Dress Coats. The Frock Coat. Scale of Measurements and Variations.

MEN'S COATS

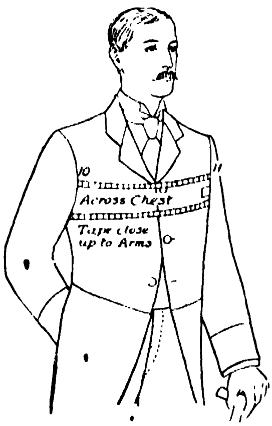
Coat and Vest. The fewest measures that are usually taken are: Nape to natural waist, 1 to 3; nape to fashion waist, 1 to 4; nape to full length, 1 to 5; width of back, 6 to 7; centre of back to elbow, 6 to 8; centre of back to wrist, 6 to 9 [15]; chest circumference, 13; waist circumference, 14; hip circumference, 15 [17]. These measures are sufficient for proportionate customers, but for others we advise the taking of four additional measures. Fasten coat in front, and then tie a piece of tape or string round the figure close up to the arms. Adjust this so that it is in the true horizontal all round.

Then take the following measures: Nape to tape on back seam, known as "Depth of Scye," 1 to 2 [15]; nape to tape at front of arm, 1 [15] to 12 [17]. From tape on back seam 2 [15] over the shoulder to the tape on the front of arm 12 [17], known as the "Over Shoulder." From the front of one arm to the front of the other arm, known as the "Across Chest" [16].



15. BACK MEASUREMENTS

These measures would stand as follows for a Lounge Jacket: Depth of scye 19; natural waist, 17; full length, 30; back width, 6¾, to elbow, 20, to cuff, 32; front shoulder, 12½; over shoulder, 17; across chest, 8; chest, 36; waist, 32; hips, 37½.

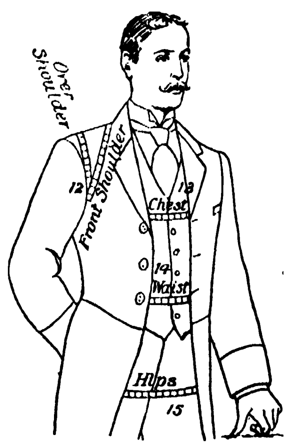


16. FRONT MEASUREMENTS

Chest.	Waist.	Scye Depth.	Lounge. Nat. Waist.	Lounge. Length.	Morning Coat. Fas. Waist.	Morning Coat. Length.	Across Back.	Full length Sleeve.	Across Chest.	Front Shoulder.	Over Shoulder.
24	24	6¼	11¾	20	..	..	5⅛	19½	5¼	9½	12¾
26	25	6¾	13	22	..	..	5½	22½	5¾	10	13⅜
28	26	7¼	14	24	..	..	5⅞	25	6¼	10½	14¼
30	27	7¾	15	26	..	..	6⅛	27½	6¾	11	14¾
32	28	8¼	16	28	18	31½	6½	30	7¼	11½	15½
34	30	8⅝	16½	28½	18½	32	6⅞	31	7⅜	12	16¼
36	32	9	17	29	19	32½	7¼	32	8	12½	17
38	34	9⅜	17¼	29½	19¼	33	7⅝	33	8½	13	17¾
40	37	9¾	17¾	30	19¾	33¼	8	33½	9	13½	18½
42	39½	10⅛	18	30½	20	34	8⅜	33½	9½	14	19¼
44	42	10½	18¼	31	20¼	34	8¾	34	10	14½	20
46	46	10¾	18½	31½	20½	34½	9	34	10½	15¼	21
48	50	11	18⅝	32	20⅝	34¾	9¼	34	11	16	22
50	54	11½	18¾	32	20¾	35	9½	34	11½	16¾	23

As many may have to work from others' measures, we give in the accompanying table a scale of measurements from 24 to 50 breast, arranged not so much with a view to proportion as the result of practical experience.

Three-seam Lounge Jacket [18]. Draw line 0—30; 0 to 3, one-third depth of scye; 0 to 9, depth of scye; 0 to 17, natural waist length; 0 to 30, full length plus ½ in. Draw lines at right angles. 0 to 2½, one-twelfth breast less ¼ in.; 2½ to ¾, ¾ in.; 17 to ½, ½ in. Draw back seam from 0 through ½ to 30. Two inches below 3, measure across from the back seam the width of back plus ½ in., curve out to ⅜; Draw shoulder seam from ¾ to ⅜, slightly hollowing it at ⅛; ¼ to 20¼, the half chest plus 2 in. to 2½ in.; 20¼ to 12¼, the across chest; 12¼ to 18¼, 6 in. (always). From 18¼ drop down 2 in. Square a line from 12¼ through C at right angles to 12¼ and 2. Measure up from 12¼ the front shoulder measure less the width of back neck. Measure up from 12¼ to B the over shoulder measure, less ¼, to A of the back. Make C to B ¼ in. less than ⅜ to ⅜ of back. Shape scye from B to 12¼ and round the back scye up to ⅜. Keep it as hollow as possible at 12¼ and rather close up at back scye.



17. WAIST AND HIP MEASUREMENTS

THE SIDE SEAMS. ½ to 6½ is one-sixth breast. Square down from 6½ and continue line up to 7½ into scye; 6½ to 7½ about ¾ in. Let fore part overlap back ½ in. more than half the difference between chest and hips; 7½ to 10, 2½ in. to 3 in.; 7½ to 10½, 2½ in. to 3 in.; 10½ to 11¼, ¾ in.

Make waist to measure plus 2 in. and so get 20¼; C to D, one-twelfth breast, less ½ in.; D to E the same amount, or to taste. Draw

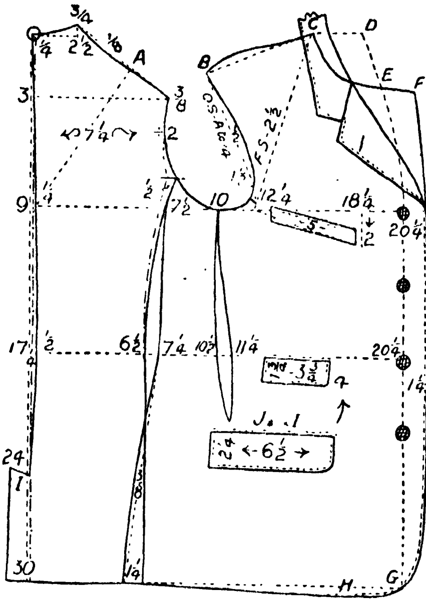
breast line from D through E and $20\frac{1}{4}$ to G. Lengthen front at H $\frac{1}{2}$ in. Add on $1\frac{1}{4}$ in. button stand for single-breasted, and $2\frac{1}{2}$ in. to $3\frac{1}{2}$ in. for double-breasted coat, and complete the front to taste.

THE SLEEVE [18A]. Mark the pitches of the sleeve as follows:

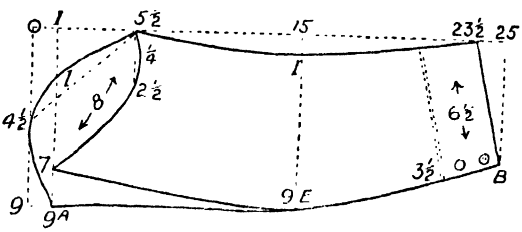
Back 2 in. below $\frac{3}{8}$. Front $\frac{3}{4}$ in. above $12\frac{1}{4}$. Draw lines at right angles to 0; 0 to 1, 1 in.; 1 to $5\frac{1}{2}$, the distance from 2 to $7\frac{1}{2}$ plus $\frac{1}{2}$ in.; 1 to 9A, the size of the scye from 2 to $\frac{3}{8}$ and B to front pitch taken straight; 0 to $4\frac{1}{2}$, half 0 to 9. Draw line from $4\frac{1}{2}$ to $5\frac{1}{2}$ and add on $\frac{3}{4}$ in. to 1 in. of round. Shape sleeve head from $5\frac{1}{2}$ and $4\frac{1}{2}$ to 9A. Measure off the length of sleeve as taken less width of back, allowing for three seams ($\frac{3}{4}$ in.), to 9E for the elbow and to B for the cuff. Hollow forearm at elbow 1 in. and shorten forearm seam at cuff $1\frac{1}{2}$ in. Make width of elbow from 1 to 9E about one-sixth breast, plus 2 in., and width of cuff one-sixth breast, plus $\frac{1}{2}$ in., or to taste.

For the underside sleeve, measure round the bottom of the scye, from back to front pitch, and apply the measure from $5\frac{1}{2}$ to 7. Square from $5\frac{1}{2}$ to $2\frac{1}{2}$ one-third of this quantity, and hollow $\frac{1}{4}$ in. to $\frac{1}{2}$ in.; curve up from 7, and continue from 7 to 9E. Complete sleeve as shown.

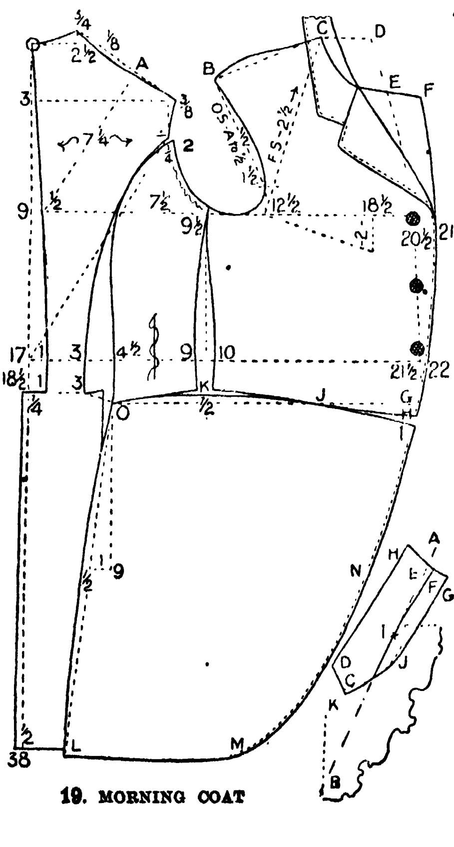
VARIATIONS. For whole back mark in from 0, $\frac{1}{4}$ in., and 30, $\frac{1}{4}$ in., and draw back seam as per dot and dash line. For slit up bottom of back seam, leave on about 1 in. at



18. THREE-SEAM LOUNGE JACKET



18A. SLEEVE



19. MORNING COAT

I about 6 in. up. To omit the fish under the arm, take out $\frac{1}{2}$ in. at the top of side seam as per dot and dash line, and allow a little more ease when measuring up the waist.

THE POCKETS. Hip pockets 4 in. below waist; 1 is midway between side seam and breast line; 1 to J is 1 in. Divide pocket flap on either side J; size of pocket same as width of sleeve at cuff. Depth about one-third of width. Ticket flap on waist front level with front of hip flap. Size of pocket usually about $3\frac{3}{4}$ by $1\frac{3}{4}$.

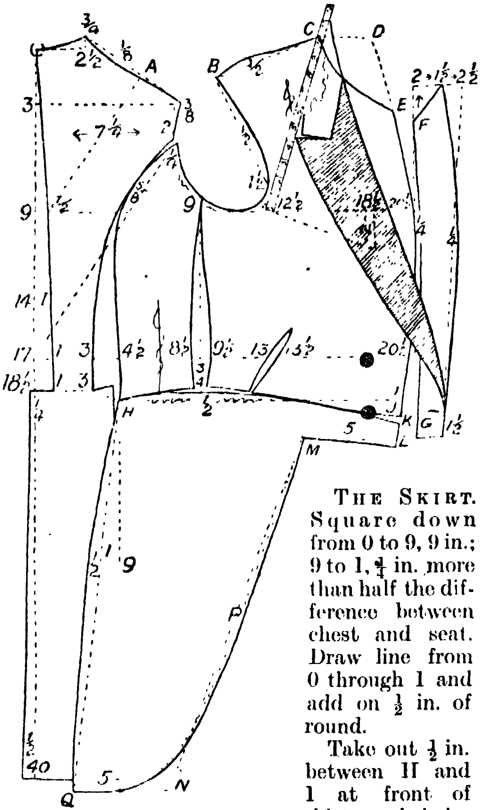
BREAST POCKET. Follow line $12\frac{1}{4}$ to 2, size about 5 by 1. Keep back end fully 1 in. in front of scye at $12\frac{1}{4}$.

Morning Coat. Shoulders same as Lounge [19]; 0 to $18\frac{1}{2}$, fashion waist length; 0 to 38, full length, plus $\frac{1}{2}$ in.; 17 to 1, 1 in.; Draw back seam, 0 to 1; 1 to 3, one-eighteenth breast.

Width of back scye $\frac{3}{8}$ to 2, the same as 1 to 3. Draw line from 2 to 17 and hollow $\frac{1}{2}$ in. to $\frac{3}{4}$ in.

Draw side seam from $\frac{1}{4}$ to 3; 3 to $4\frac{1}{2}$, $1\frac{1}{2}$ in.

Take out $\frac{1}{4}$ in. at 2. Make 2 a pivot, and sweep from 3 to 0; $\frac{1}{2}$ to $9\frac{1}{2}$ one-fourth breast; 9 to 10, 1 in. Make up waist to measure, plus 2 in. Hollow waist seam 1 in. at K, and drop it 1 in. at H. Add $1\frac{1}{4}$ in. button stand beyond breast line, and complete run of fronts to taste.



21. DRESS COAT

THE SKIRT. Square down from 0 to 9, 9 in.; 9 to 1, $\frac{1}{4}$ in. more than half the difference between chest and seat. Draw line from 0 through 1 and add on $\frac{1}{2}$ in. of round.

Take out $\frac{1}{2}$ in. between H and 1 at front of skirt, and $\frac{1}{4}$ in. at K. Shape the front of skirt, 1, N, M, and L to taste.

THE COLLAR. Dotted line indicates the neck of forepart. B is $\frac{1}{4}$ in. above top buttonhole. J to I is $\frac{1}{4}$ in. less than collar stand.

Draw line from B through 1 to E. E to G, the depth of fall. G to F, the depth of stand. F to H, the depth of fall. G is the width of back neck from fore part. Follow the neck from J to C, letting it overlap $\frac{1}{4}$ in at C. C to D to taste. B 1 F is the crease row.

Frock Coat. Similar to Morning Coat in body and shoulder parts up to the breast line D to 1, in the front of which add on $\frac{1}{2}$ in. at E; $\frac{1}{4}$ in. at F to nothing at 1 [20].

The lapel is drawn straight from 0 to G. 0 to 2, 2 in. 2 to $1\frac{1}{2}$, $1\frac{1}{2}$ in. 2 to $3\frac{1}{4}$, $3\frac{1}{4}$ in. Complete as shown.

THE SKIRT. I to J 2 to 3 in. J to L is a straight line from which square down to 9 9 in. 9 to 1, 1 in., or $\frac{1}{4}$ in. more than half difference between chest and seat.

Add on $\frac{1}{2}$ in. of round. O to P, $\frac{3}{4}$ in; draw waist seam from L through P to K. K is $\frac{1}{2}$ in. less than the width of lapel in front of J.

Drop down from L 2 in. to 3 in. to agree with H to J, and square K N at right angles. K to N the same length as L to M of back. This diagram shows the medium turn with the fronts buttoning three; a higher turn with the fronts buttoning four (this style should have the lapel hollowed at the top $\frac{3}{4}$ in.), and a low roll with the fronts buttoning two (this should have the lapel rounded $\frac{3}{4}$ in. in order to get a shorter outside edge).

Dress Coat. The shoulders and body parts are cut in the same way as the morning coat, with the following exceptions [21]. Point E on the front of neck is lower 1 to $1\frac{1}{2}$, so that D to E equals one-eighth breast. The waist between 1 and $20\frac{1}{2}$ is made up to half the waist measure only, making allowance for what is taken out between 3 to $4\frac{1}{2}$, $8\frac{1}{2}$ and $9\frac{1}{2}$, and 13 and $13\frac{1}{2}$.

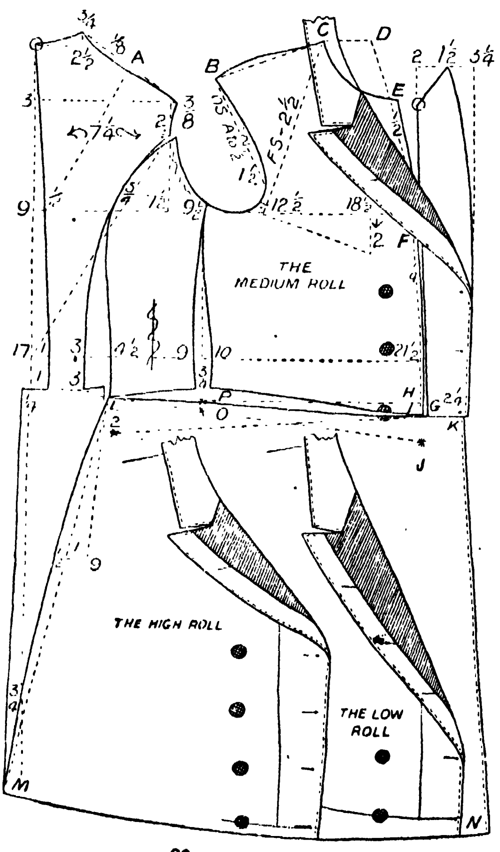
THE LAPEL. Draw a straight line and hollow $\frac{1}{4}$ in. to $\frac{1}{2}$ in. From F come up 2 in. and go forward $1\frac{1}{2}$ and $2\frac{1}{2}$. The length of the lapel should be sufficient to cover the bottom of the strap of skirt. Width of the lapel at bottom $1\frac{1}{2}$. Draw a line from $2\frac{1}{2}$ to $1\frac{1}{2}$ and add on $\frac{1}{4}$ in.

THE SKIRT. The back and top parts of skirt are the same as for the morning coat, the proportions of the other parts being as follows:

K to L, $1\frac{1}{2}$ in. L to M, one-third of the width of skirt at top. Q to N, one-third of the top. Draw line from M to N, add on a little round.

Sometimes the back is cut $\frac{1}{4}$ in. narrower all through with the view of making it lighter and smarter looking, but this is a matter of taste, and we have kept to the same style as the morning coat for the sake of simplicity.

W. D. F. VINCENT



20. FROCK COAT

The Occurrence and Metallurgy of Nickel and Cobalt. Their Properties, Preparation, and Uses. Nickel Alloys.

NICKEL AND COBALT

In the early part of the eighteenth century there was an arsenious ore which much troubled Swedish and German miners, owing to its deceptive resemblance to native copper. They termed it *koppar-nickel* or *kupfernickel*, "devil's worthless copper," from a form of the German *nicklaus*, which is represented in English by "Nick," "Old Nick." Cronstedt examined it, and in 1754 isolated the metal contained and, reasonably enough, called it nickel. The closely allied metal cobalt probably got its name in similar fashion from the German *kobold* (goblin) on account of its poisonous and troublesome mining character.

Properties. Nickel and cobalt are hard metals related, chemically, very closely to one another and to iron, belonging to the iron group of metals in the Periodic System of Newlands and Mendeléeff. They are nearly always found in association. Nickel (Ni, atomic weight, 58·77) is a white metal with a brilliant lustre which is but slightly tarnished by air, moist, dry, or carrying carbon dioxide, at the ordinary temperatures. Cobalt (Co, atomic weight generally given as 59, but uncertain; a value found in 1906 is 58·895) is a reddish-white metal which is untarnished in air. Both metals, when finely divided by reduction from their oxides with hydrogen, spontaneously ignite in air, and on both a scale of dark-coloured oxide is formed when strongly heated.

Nickel has a specific gravity of 8·35, increased by rolling to from 8·6 to 8·9, and cobalt one of 9·0. The specific heat of pure nickel is given by Roberts-Austen as 0·1108 and by Regnault as 0·1086, iron being 0·113 (Roberts-Austen). Its coefficient of linear expansion for 1° C. is 0·0000127 (Roberts-Austen), compared with 0·0000121 for iron. The melting-point of nickel has been variously determined at from 1390° C. to 1500° C., while the fusing-point of cast iron is from 1135° C. to 1220° C. (Roberts-Austen); pure, 1600° C. (Hiorns). Cobalt is slightly more fusible than iron. When molten, nickel occludes carbon monoxide, which is given out on cooling, rendering the metal porous.

Nickel is a very hard but malleable and ductile metal, and has been rolled and hammered into sheets not more than 0·0008 in. thick, and drawn into wire not exceeding 0·004 in. in diameter. Its tensile strength has been said to exceed that of iron. St. Claire Deville found that a nickel wire containing 0·3 per cent. of silicon and 0·1 per cent. copper bore a strain of 200 lb., while a similar iron wire broke at 133 lb.; while Kollmann found that the tensile strength of a specimen of Westphalian nickel equalled that of medium hard Bessemer steel. The results given in the table below were obtained by Mr. R. A. Hadfield for 98·8 per cent. cast and forged nickel. The comparative values given for iron are by Professor Arnold for 99·8 per cent. cast and forged iron.

With 98 per cent. cold rolled nickel, Fremont (of Le Nickel Compagnie) obtained an elastic limit of 22 tons per square inch. The metal is easily welded at a white heat both with itself and to iron and to certain other metals; this property is the basis of an excellent nickel-plating process.

Nickel is magnetic, though not equally with iron (1 : 1·5); cobalt is only slightly magnetic. Both metals are said to lose their magnetism when heated to about 350° C. Their relative electric conductivities (100 being taken as the standard for silver) are 12·89 and 16·9 respectively.

Nickel is slightly acted upon in the cold by hydrochloric and sulphuric acids, but dilute nitric acid and *aqua regia* dissolve it readily. It is, however, but very slightly attacked by organic acids and the alkalies. Fused alkalies oxidise platinum; and nickel, therefore, replaces this metal for laboratory crucibles and other vessels used for melting alkalies.

Nickel and Cobalt Ores. Nickel is comparatively a non-abundant element. It is present in the sun's atmosphere, and has been found in meteorites. It is very rarely found native. Its ores are complex mixtures, divisible into three classes: sulphides, silicate, and arseniferous. Cobalt ores are almost invariably associated with nickel ores, and cobalt frequently replaces nickel in part.

The most important mines are those of Sudbury, Ontario (sulphides), and of New Caledonia (silicate). Mines in different parts of Europe produce smaller quantities of arseniferous ores. Almost the whole of the 11,810 tons of nickel produced in 1904 came from the Sudbury and New Caledonian ores.

The largest deposit is probably that of the great nickeliferous district of Sudbury, covering about 2800 square miles. Here the ore consists of a mixture of chalcopyrites ($Cu_2S.Fe_2S_3$) and pyrrhotite, a monosulphide of iron, part of the iron and copper in the two minerals, varying from 2½ per cent. to 10 per cent. (partly with the depth of the deposit), being replaced by nickel. This is a sufficiently large proportion to make the deposits pay as nickel ores, the copper (practically the whole produced in the province of Ontario) being a by-product. The ore is not found in veins but in irregular lenticular masses and pockets.

TENSILE STRENGTHS OF NICKEL AND IRON COMPARED

Quality of Metal	Elastic Limit. Tons.		Tensile Strength. Tons.		Elongation. Per cent.	
	Nickel.	Iron.	Nickel.	Iron.	Nickel.	Iron.
Cast (unannealed) ..	11	14	16·25	20	4·5	16
Forged (unannealed)	14	14	32·2	22	45·5	47
Forged (annealed) ..	7	—	31·25	—	54	—

Millerite (NiS), a valuable source of nickel, is sometimes found with the Sudbury pyrites.

The ore of New Caledonia is *garnierite* [(NiMg) $SiO_3 + n\,H_2O$], a silicate containing from 7 per cent. to 8 per cent. of nickel, 41 per cent. to 46 per cent. of silica, and oxides of iron, aluminium, and magnesium, found by Garnier in 1875. It is free from arsenic, sulphur, and copper. Other nickel ores are the blende, glance, cobaltic pyrites, and kupfernickel, found in smaller quantities in various parts of Europe. Smaltine, cobaltine, and cobalt bloom are European arsenious cobalt ores.

Treatment of Ores. There are many nickel ore reduction processes, but the commercial and the important ones come under three heads: copper ores (chalcopyrites) by two processes only, the Mond and Orford; silicate ores (garnierite) by repeated reverberatory roastings; and arsenical and sulphurous ores by the production of a matte or speiss. In all processes nickel oxide is produced which is reduced to the metal.

The first process in treating the sulphurous ores of Sudbury is roasting. After crushing and sorting, the ore is roasted in heaps of from 600 tons to 1,800 tons, piled up on a bed of wood to about 6 ft. or 8 ft. high. The heaps are allowed to burn for from six to ten weeks, whereby the sulphur content is reduced from 22 per cent. to 7 per cent., the iron partly oxidised, and the ore disintegrated and reduced to a matte.

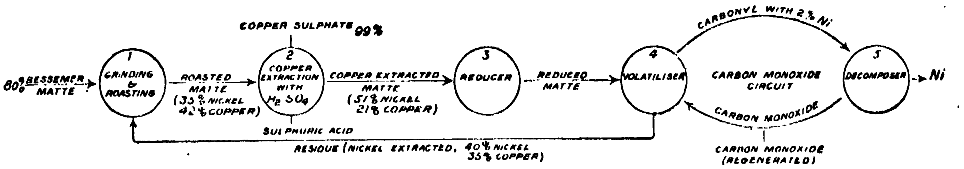
The silicate (New Caledonian) ores do not require the preliminary roasting. At first their purity induced their discoverer to work them direct in wind furnaces on the same principle as that by which pig-iron is produced. But this process has been abandoned because it was found impossible to remove sulphur entirely, and a matte is produced by smelting in a water-jacketed furnace with sulphur or salt-cake. This matte is powdered and roasted with quartz sand two or three times to reduce the percentage of iron. The nickel is then oxidised by double roasting in a reverberatory furnace (the iron and sulphur being driven off) and the oxide reduced by heating cubes of it, made with flour or other paste, in a muffle or crucible furnace.

Bessemer-refined nickel matte (containing 24 per cent. of sulphur, 75 per cent. of nickel, and about 0·5 per cent. of iron) cannot be further treated in the converter, partly because the nickel oxidises with the sulphur, and also because, with the reduction of the proportion of sulphur, the melt tends to solidify.

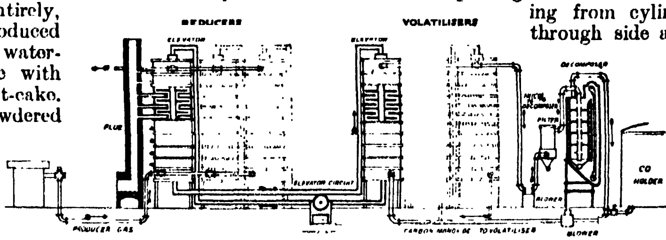
Sudbury matte contains copper, and the nickel can be extracted from it in the dry way only by the Mond and Orford processes.

The Mond Process. This is the only process in metallurgy where the metal sought forms a gaseous compound during the process of recovery. It depends upon the fact, accidentally discovered by Drs. Mond and Lange in 1889, that at about 50° C. nickel forms a volatile poisonous compound with carbon monoxide, known as *nickel carbonyl*, $Ni(CO)_4$, which is entirely dissociated by raising the temperature to 150° C. Iron is the only other metal which forms such a compound. Several patents were taken out, and the Mond process has been commercially operated since the beginning of 1902, at Clydach, near Swansea. The principal operations of the process are shown diagrammatically [1]. Cupriferous nickel ore mined at Sudbury is roasted and concentrated by Bessemerising, and the matte obtained, containing from 30 to 40 per cent. of nickel and about 45 per cent. of copper, is ground in ball mills at the works in South Wales, and calcined to form nickel oxide and drive off sulphur and arsenic. It is then leached with sulphuric acid, about half the copper being extracted as sulphate, which is crystallised out and sold. A diagrammatic representation of the plant used is given in 2. The copper-extracted matte, which is separated by filtration and centrifugalisation, is carefully reduced in reduction towers with water or producer gas. In order to prevent the formation, later on, of iron carbonyl, it is necessary at this stage to keep the temperature as low as possible, so that iron oxides may not be reduced. This regulation of temperature is achieved in the reducers, which are built up of a number of short cylinders, with hollow bottoms, through which combustion gases from a flue, or water, or air, may be circulated for heating or cooling. The water gas rises through the towers, passing over a stream of matte, descending from cylinder to cylinder, through side and central openings by means of stirrers, reducing the oxide to crude metal. The reduced nickel is conveyed by means of elevators to the volatilising towers, where carbon monoxide is passed over it in a similar manner to the reduction treatment. The volatilisers are similarly constructed of cylinders, without hollow bottoms, however, the heat of the material from the reduction towers and of the gas rising through being sufficient to maintain the temperature of 50° C. required for the formation of nickel carbonyl. The nickeliferous material circulates by means of elevators among the volatilisers for from seven to fifteen days, to complete the formation of carbonyl.

The nickel carbonyl gas is then drawn by means of a blower through a filter (to remove flue dust) into the decomposing tower. Here the gas passes over



1. DIAGRAM OF OPERATIONS OF MOND NICKEL PROCESS



2. MOND NICKEL PLANT

granules of metallic nickel, kept in motion to prevent cohesion, at a temperature of about 200° C., by means of which it is broken up into nickel and carbon monoxide, the metal being deposited on the granules, and the gas released and returned to the volatiliser. The reaction is shown by the equation $Ni(CO)_4 = Ni + 4CO$. The granules are essential to start the decomposition. The pellets produced are particularly suitable for alloying. They contain from 99·4 to 99·8 per cent. of nickel, never more than 0·5 per cent. iron, and traces of sulphur and carbon.

The process is somewhat delicate, owing to the temperature conditions which have to be observed; but, from the fact that nowhere does it exceed 300° C., the fuel consumed is small in amount, and the repairs to the plant inconsiderable. It is automatic and also regenerative so far as the carbon monoxide is concerned. Sir James Dewar took out a patent in 1902 by means of which the process of carbonyl formation is considerably shortened.

The Orford Process and Speiss Extraction. In the Orford or separattion-smelting process, a nickel-copper matte is smelted with salt-cake and coke, producing "tops" and "bottoms," which are re-smelted. The nickeliferous sulphide bottoms obtained are roasted with salt in a reverberatory furnace, nickel oxide being formed. This is leached out and reduced with coke in the furnace to crude metal. Until 1903 the nickel so produced was electrolytically refined, but as nearly half the charge became anode scrap in the process, it had to be abandoned when metal over 99 per cent. pure was produced by the carbon-reduction and Mond processes.

Nickel speiss is produced from arseniferous ores, or, with matte, from a cupro-arseniferous ore, by oxidation with silica. The metals pass in a regular order into the slag as silicates, cobalt and nickel going last. Unoxidised arsenides form a speiss, which sinks through the slag. When only a nickel and cobalt speiss remains, this is re-fluxed and re-fused to obtain a nickel speiss with a cobalt slag. The speiss may then be worked up by roasting, or, if a particularly pure nickel is required, by the complicated wet process consisting of a series of about sixteen precipitations and other chemical operations.

Electro - chemical Treatment. No known ore of nickel is pure enough or contains enough nickel to be directly electro-chemically treated. Electrolysis is not at present practically applicable to nickel mattes. High potentials are necessary to deposit nickel from solution, and these cause most other metals to be co-deposited. A thick deposit of nickel is therefore very difficult to obtain, although there is nothing lacking in the thin coating obtained in nickel-plating. Electrolytic refining of nickel and cobalt is also impracticable, but a copper-nickel alloy is produced by an electrolytic process from mattes.

Refining. Formerly coarse nickel contained as much as from 10 to 40 per cent. of impurities, but metal 98 per cent. pure is now readily obtained from any ore, while Mond nickel is from 99·4 to 99·8 per cent. pure. The chief impurities are iron (1 per cent. destroys extensibility in German silver); sulphur and arsenic (1·1 per cent. of either renders nickel unsuitable for rolling); nickel oxide (0·3 per cent. makes it brittle); and chlorine (0·18 per cent. makes German silver unrollable). Cobalt, copper, and silicon in small quantities do not injure nickel. The absence of these impurities is aimed at by making as pure a nickel oxide in the preliminary processes as possible. Fleitmann found that magnesium effectively removes these small amounts of impurities, which at first prejudiced the use of nickel in alloys. It was added as a nickel alloy in amounts less than $\frac{1}{8}$ per cent. Aluminium has now entirely superseded magnesium for this and similar purposes.

Nickel Alloys. The largest use for nickel is in its alloys, German silver and nickel-steel. On account of its non-tarnishing properties and power of taking a high polish, it is very largely used to coat other metals.

Nickel-brass alloys are harder, stronger, and more chemically resistant than brass, while nickel-steel alloys are harder, tougher, and more tenacious and ductile than steel; but they are somewhat delicate mixtures, and are affected by very small quantities of the foreign metals mentioned above. For instance, nickel smelted in the old way from speiss always contained arsenic. The introduction of nickel alloys was thus prevented for a long time. Nickel is used in alloys either as the spongy mass which is produced by carbon reduction of the oxide, as Mond pellets, or as the oxide, the latter being largely used for nickel-steel. Nickel alloys containing more than 25 per cent. of nickel are always white, owing to the great colouring power of the metal.

German Silver. German silver is a brass with the addition of nickel. It is an alloy in widespread use, and was prepared by the Chinese, long before nickel was known as a metal, by melting copper with nickeliferous minerals. It was similarly prepared in Europe in 1770. It is also known under the names nickel silver, argentan, neusilber, packfong ("white copper") and maillechort. Nevada and Virginia silver, silveroid, silverite, electrum, etc., are varieties of the same alloy, with different proportions of the constituents, and, perhaps, also containing cobalt, iron, or manganese. German silver is valuable on account of its whiteness and capacity for polish, hardness, toughness, malleability, and ductility, and its chemical resistance to air and weak food acids. German silver is crystalline, and cast plates crack on hammering. The crystalline structure is destroyed by rolling and hammering operations, with frequent annealings, and the metal is then easily worked under the stamp or in the rolls, provided the metals used in alloying are pure. In making German silver, the alloying metals are used as binary alloys—a nickel and copper alloy being mixed with brass. Modern proportions for the alloy vary very considerably. Some of the representative formulæ are given in the following table.

COMPOSITION OF GERMAN SILVER ALLOYS

Name.	Nickel.	Copper.	Zinc.	Remarks.
The ideal alloy	34	46	20	The best for beauty, lustre, and working
Extra white metal ..	30	50	20	
Berlin argentan	26	52	22	
Electrum	25·8	51·6	22·6	
For spoons, forks, etc. ..	25	50	25	Blue-white, untarnishable
Coin metal	25	75	—	Continental coinage
White metal	24	54	22	
Sheffield	24	57	19	
Best best	21	50	29	
Firsts	16	56	28	
Packfong	15·6	43·8	40·6	Chinese alloy
Thirds	12	56	32	
Fifths	7	57	36	For plated goods

Platinoid is a German silver with 2 per cent. of tungsten added. It has the properties of German silver, but its electric resistance is $1\frac{1}{2}$ times greater, and changes only 0·0209 ohm per degree between 0° C. and 100° C., whereas German silver changes 0·044 ohm per degree, and copper 0·38. Its resistance, therefore, being very high, and approximately constant, it is largely used for resistance boards and similar purposes.

Nickel-Steels. Nickel added to steel raises its elastic limit and tensile strength, and increases its hardness and its resistance to alternating stress, impact, or shock, without seriously lowering its extensibility. It had long been noted that meteoric iron is tougher, more malleable, and less easily corroded than ordinary iron, and it was known that nickel was present, but it was not until pure nickel was obtainable that alloys with iron were successfully made. Most hardening constituents of iron and steel make the metals brittle, but nickel and manganese are exceptions.

The strength factors of representative nickel-steels are shown in the table given below. For ordinary soft steel the limit of elasticity is about 13 tons, and the ultimate strength from 22 to 35 tons per square inch.

The combination of ductility with strength and hardness particularly fits nickel-steel for armour, and it is probable that no armour or deck-plate is now made that does not contain from 3 per cent. to 5 per cent. of nickel. The best armour plate yields by perforation rather than by fracture. Nickel-steel armour was adopted by the British Navy in 1896. In an official test made some years ago an ordinary face-hardened (cemented) plate cracked and fractured under test, while a Krupp nickel-steel plate, 6 in. thick, which was attacked by guns of equivalent weight, did not crack, and the projectiles rebounded, owing to the elasticity of the plate. The projectiles, which were fired at a hardened nickel-steel Vickers plate, 11·8 in. thick, would have perforated an iron plate 26 in. thick, but they broke against this plate, leaving their heads imbedded, without cracking it. Krupp plate contains 3·5 per cent. of nickel, 1·5 per cent. chromium, and 0·25 per cent. carbon.

On account of its high elastic limit, nickel steel is of great importance for gun-steel in combating the fatigue induced by repeated high-firing stresses. Its high elastic limit, combined with ductility, also gives it value for marine shafting where there are continual variations of alignment, owing to wave shocks, the indefinite repetition of which means rupture of the shaft. The use of a 3·25 per cent. nickel-steel shaft instead of ordinary steel multiplied by six the number of rotations before breaking. In a series of American flexure tests, a 5 per cent. nickel-steel tube bore 1,000,000 flexures, compared with 100,000 for a 0·1 per cent. carbon steel. Its resistance to alternating stress and shock renders it exceptionally serviceable in high-speed engine parts, marine shafting (as mentioned above), girders, stanchions, railway axles and tyres, and hull plates (nickel-steel is less corroded in salt and fresh water than steel), where rigidity without brittleness is required. Its greater strength permits decrease in weight, or an increased safety factor. It is also of value in tool-steels, steam-hammer and rock-drill piston rods, hydraulic cylinders, and similar high stress apparatus.

Cobalt has a similar influence on steel, but its limited supply prevents it competing with nickel.

Nickel-steel is made in the open-hearth furnace, in the ordinary way, with ferro-nickel or nickel oxide.

Cobalt Compounds. Cobalt would compete with nickel in many respects if it were obtainable in greater quantities, but, the supply being limited, its compounds are the only forms in which it is used.

Cobalt forms two oxides—the protoxide, CoO, and the sesquioxide, Co_2O_3. The protoxide forms numerous salts. The chloride and nitrate in weak solution forms sympathetic inks, turning bluish-green on heating, fading away again, if they are not too strongly heated to form a basic salt. The sesquioxide is of no practical value. It forms no salts. The protoxide is the basis of all blue colours used in glass and porcelain work. *Smalts* is a glass-cobalt oxide, melted with quartz sand and potassium carbonate. Fine smalts was used for bluing paper, but is superseded by artificial ultramarine. *Zaffre* is a fritted silicate made by heating the oxide with quartz. It produces a deep blue glass when fused with a carbonate. Other cobalt colours are *cobalt blue* (a mixture of the hydrated oxides of cobalt and aluminium), *Thenard's blue* (cobalt and aluminium phosphate), and *Rinman's green* (zinc and cobalt oxides).

In making smalts, fairly pure arsenical ores are calcined in a reverberatory or muffle furnace (with arsenic condensing chambers), mixed with glass-house sand and potassium carbonate, and fused in glassmakers' pots.

COMPARATIVE STRENGTHS OF REPRESENTATIVE NICKEL-STEELS

Authority.	Condition	Nickel. Per cent.	Carbon. Per cent	Manganese. Per cent.	Elastic limit. Tons per sq. in.	Maximum Stress. Tons per sq. in.	Area reduction. Per cent.
Arnold		1·51	0·11		22·45	26·8	62
Sankey & Smith	Annealed	2·95	0·32	0·512	21·7	39·3	58·6
	Do. (Sheffield)" ..	3·01	0·28	0·516	21·9	39·2	49·3
	Oil-tempered (German)	4·175	0·31	0·615	23·7	50·4	54·3
	Rolled and annealed"	5	0·5	0·34	32·5	46·8	—
Riley	Do.	25	0·82	0·52	15·1	42·1	43·6

Object and Methods of Preparation. Totals and Balances. · Errors Disclosed and Undisclosed. Compensating Errors.

THE TRIAL BALANCE

There are in many cases factors other than goods and returns to be taken into account in order to arrive at a true statement of gross profit. For instance, there are the items of freight, duty, and carriage, which add very largely to the cost of purchases from abroad. We cannot exactly describe them as "goods," but neither are we at liberty to ignore the bearing which they have upon the question of gross profit.

Trading Account. Evidently, we must have an account more comprehensive in its title than the goods account, one that will embrace all items which directly affect gross profit on trading. At the same time, we require that this account shall be easy of interpretation and analysis, and to that end we must take care that it is simple and concise. Our requirements are met by the "trading account," which, unlike the goods account, is not opened until the end of a business period. Under this plan provision is made for the monthly totals of purchases, sales and returns, which have hitherto been posted to goods account, by raising separate accounts for purchases and sales in the private or in the general ledger. To the debit of purchases account are posted the monthly totals of the invoice book, and to the credit of the same account are posted the monthly totals of the returned outwards book, the difference between the two sides representing net purchases.

Closing the Account. The account is closed by means of a transfer entry passed through the journal and posted to the ledger, crediting purchases account and debiting trading account with the amount of such difference. To the credit of sales account are posted the monthly totals of the day book or sales journal, and to the debit of the same account are posted the totals of the returned inwards book for the period, the difference between the two sides representing net sales. The account is closed by means of a transfer entry passed through the journal and posted to the ledger, debiting sales account and crediting trading account with the amount of the difference. The item "stock in trade" or "stock on hand," instead of appearing in the goods account as heretofore, is now shown in a separate account headed "Stock," the amount on hand at the beginning of a period being on the debit side, in accordance with the rule for real accounts to "debit what comes in." At the end of the period, stock account is relieved of this old debit, being simultaneously burdened with a new debit for the value of the stock on hand as ascertained by stocktaking.

Here, again, recourse is had to transfer entries in the journal. So far as the old stock is concerned, trading account has had the benefit of it, and we therefore credit stock account and debit trading account with the value of the stock at the beginning of the trading period. But with regard to stock on hand at the end of the trading period, it is clear that this must form part of the goods purchased during that period, and perhaps there is, besides, some of the old stock still unsold. We must, therefore, relieve the trading account to the extent of the present value of the whole of the unsold goods reckoned at cost or under; and this we proceed to do by passing another transfer entry through the journal, debiting stock account and crediting trading account. So far, then, we have on the debit side of trading account two items:

(*a*) Stock on hand at beginning of period, (*b*) net purchases during the period; and on the credit side two items: (*a*) stock on hand at end of period, (*b*) net sales for the period.

Other Charges. But in many businesses—the wholesale confectionery business, for example, —freight, duty, etc., must be added to the cost of the purchases before we can arrive at a true balance of gross profit. Accordingly, an account headed "freight, duty, carriage, etc.," is opened in the general ledger, and to this account are posted all cheques and petty cash payments made throughout the trading period on account of imports and other purchases on trading account. If at the end of the period there are any outstanding accounts for freight, warehouse and rail charges, cartage, etc., they must be journalised by debiting the carriage, etc., account and crediting a sundry creditors' account. By this means the whole of the expenditure proper to purchases for the period will be shown regardless of whether it has actually been met or is still due at the time of stocktaking. The account is closed by means of a transfer entry passed through the journal and posted to the ledger, debiting trading account and crediting freight, duty, and carriage account, with the debit balance shown on the latter.

Reproductive Wages. There are, moreover, a great many manufacturing concerns which purchase raw material and expend labour upon it, relying upon the sales of the finished product to return them a satisfactory gross profit. In such cases we should raise a separate account for reproductive, or manufacturing wages. Such wages are called *reproductive* because, although they represent an addition to the cost of the purchases, they also add to the value of the articles offered for sale,

and may therefore be regarded as recoverable out of the sums realised for sales. The manufacturing wages account is thus a part of the trading account, and at the end of the business period will be closed by the transfer of the total net debit to the trading account itself.

Gross Profits. We have now considered the chief ingredients in the trading account. Special notice is to be taken of the fact that the trading account, consisting as it does of an aggregation of the balances of various subsidiary accounts, serves to focus the whole of the business operations throughout a given period which affect the ultimate gross profit. If there is, as there certainly ought to be, a credit balance on trading account, this is the measure of the gross profit earned, and the trading account is closed by debiting the amount of the gross profit thereto and crediting it to the profit and loss account. Where a combined trading and profit and loss account is adopted, it is scarcely necessary to make a journal entry for transferring the gross profit from trading to profit and loss account; it is sufficient, if the upper (trading) portion of the combined account is balanced off by placing the gross profit balance on the debit side thereof and bringing it down on the credit side of the lower (profit and loss) portion of the combined account.

The Trial Balance. Before proceeding to deal further with the balance thus transferred to the profit and loss account, it will be well to retrace our steps a short distance for the purpose of considering the means by which the accuracy of the records in the books is proved. This depends on the cardinal rule that as every debit has a corresponding credit of similar amount, the total of all the debits must equal the total of all the credits, if the work of entering the ledger has been accurately performed. It would be useless for a trader to prepare an account purporting to show the amount of his profit or loss until he knew that his books were free from errors. Therefore he takes steps to ascertain whether that is so by preparing what is called a trial balance.

The manner of doing this is as follows: A list of all the accounts in the ledger is prepared on paper ruled with two cash columns, and either the totals of the debits and credits on each account are inserted in the left-hand and right-hand columns respectively, or the balances only of the accounts are inserted according to whether they are debit or credit balances. When an account has the same amount entered on the debit side as on the credit side, both amounts are omitted from the trial balance, as the agreement of the gross totals of debits and credits will not be affected, because both will be decreased by the same amount.

This principle of omitting similar amounts from both columns is carried a step farther. As the omission of a like amount from both debit and credit columns does not affect the agreement of the gross totals, the smaller of the two totals on each account is deducted from the larger, and only the difference is inserted in the list of ledger accounts in the appropriate column. In other words, only the balance of each account is included in the list or trial balance.

Total and Balance Methods. These facts point to two conclusions:

(1) That those accounts which have the same total amount on the debit as on the credit side may be omitted from the trial balance.

(2) That it is necessary to include in the trial balance only the balances, and not the totals of the remaining accounts.

To show quite clearly that we are justified in arriving at these conclusions, and that the omissions may safely be made without impairing the usefulness of the trial balance, the careful attention of the student is directed to the table given on the next page, showing side by side the two methods.

This table should enable the student easily to understand why agreement is obtained between the totals of the debit and credit columns of a trial balance consisting of the balances of ledger accounts, because it shows clearly that the balance of an account is the amount remaining after deducting the same amount from each side. Thus, in the case of "Bank," the amount of the smaller side—the credit—is deducted, leaving £414 3s. 2d. in the debit column, and nothing in the credit column. In the case of "Sales," the smaller amount being in the debit column, the sum of £152 10s. 0d. is deducted, leaving nothing to debit, and £6547 10s. 0d. to credit.

Closed Accounts Omitted. It is obvious, having regard to the amount of the purchases and sales, that all the accounts in Smith & Jones' ledgers have not been brought into the trial balance. Our personal accounts number only eight in all, while the transactions to which they relate amount to only some £1700 to £1800. The only reason for the omission of the rest of the personal accounts is consideration of space, and their non-inclusion does not affect the agreement of the gross totals, as their debits and credits must be equal.

The plan of preparing the trial balance by showing the totals rather than the balances of the several accounts has only one real recommendation, and even that is not applicable to modern methods of bookkeeping. When every transaction was entered in detail in the journal, and posted thence separately to the ledger, the trial balance on the total system provided an additional check on the accuracy of the work, in that the gross totals agreed with the totals of the debit and credit columns of the journal. As we have seen, however, modern requirements have forced the business community to adopt labour-saving devices in regard to accounts as in other matters. The existence of several journals would render the obtaining of such a check somewhat difficult, and the result would hardly justify the labour entailed.

The Balance Method. But there is another and more weighty reason for the adoption of the balance system. A trial balance made up of the balances of the open ledger accounts contains within itself all the materials necessary

TRIAL BALANCE EXTRACTED FROM THE LEDGER OF SMITH & JONES, ON 31ST DECEMBER, 1905

Name of Account.	Totals.		Balances.	
	Debits.	Credits.	Debits.	Credits.
Bank	4,621 17 3	4,207 14 1	414 3 2	—
Cash	87 16 8	74 18 2	12 18 6	—
Stock	1,750 0 0	—	1,750 0 0	—
Purchases	5,250 0 0	105 15 0	5,144 5 0	—
Sales	152 10 0	6,700 0 0	—	6,547 10 0
Wages	725 16 0	—	725 16 0	—
Salaries	357 10 0	—	357 10 0	—
Freight and carriage	146 8 6	—	146 8 6	—
Rent, rates and taxes ..	350 0 0	—	350 0 0	—
Discount	75 14 9	52 13 6	23 1 3	—
Miscellaneous trade expenses..	109 16 2	—	109 16 2	—
A. Black..	206 8 0	5 8 6	200 19 6	—
T. Hall	74 6 3	74 6 3	—	—
G. Brown	199 2 6	2 10 11	196 11 7	—
C. Robinson	220 0 0	220 0 0	—	—
F. White	16 8 3	222 1 1	—	205 12 10
J. Harris	62 10 8	62 10 8	—	—
S. Grey	14 9 1	178 19 0	—	164 9 11
W. Green	201 11 6	15 8 5	186 3 1	—
Smith, capital account ..	—	1,500 0 0	—	1,500 0 0
Do. drawing account ..	150 0 0	—	150 0 0	—
Jones, capital account ..	—	1,500 0 0	—	1,500 0 0
Do. drawing account ..	150 0 0	—	150 0 0	—
	£14,922 5 7	14,922 5 7	9,917 12 9	9,917 12 9

for the preparation of the profit and loss account and the balance sheet, with the exception only of the amount of the stock on hand at the close of the trading period.

This reason alone would have been sufficient to bring about the adoption of the balance method, in preference to the total method; but when it is realised that there are in a business of moderate size many accounts where both sides agree in total—*i.e.*, where debits equal credits—it scarcely need be stated that the balance method is used by accountants owing to the amount of labour saved by their being able to omit such accounts from the trial balance.

Object of Trial Balance. It is the desire of every trader to ascertain periodically (1) what are his profits or losses; and (2) what is his present position as regards assets and liabilities. To obtain the answer to these questions, he must prepare a profit and loss account and a balance sheet. But before he can begin to do this he must first know that the work of recording his commercial transactions in his books has been correctly performed. The trial balance goes a very long way toward giving him this information, and it is, perhaps, no exaggeration to say that when a merchant or his accountant arrives at an agreement in his trial balance, he assumes the correctness of the work as a whole, and proceeds to the preparation of the profit and loss account and balance sheet. It should be mentioned, however, that there are certain errors which are not disclosed by a trial balance, and which may exist, although the gross totals of the latter agree. That is a matter which will engage our attention presently, but which need not detain us now. The importance of the trial balance in relation to the final accounts—*viz.*, the trading and profit and loss account, and the balance sheet—cannot be over-estimated. Indeed, it needs very little consideration on the part of even a tyro to appreciate the necessity of proving the accuracy of the books before proceeding further. The manner in which the test of accuracy is applied is by the preparation of a trial balance. This, as already shown, consists of a list of all the open ledger accounts, arranged with debit and credit columns, in which are entered the balances. It must be clearly understood that the trial balance forms no part of the general scheme of accounts, and is not entered in the ledger or any other book. It is made up on loose sheets, and its object is to ascertain if the debit and credit sides of the ledger agree.

Errors Disclosed by Trial Balance. If the totals of the debit and credit columns of the trial balance do not agree, it is useless to proceed to construct the balance sheet until the cause of the difference has been ascertained. Before beginning a search in the ledger and other books, the bookkeeper will first make sure that the error is not in preparing the trial balance itself. The casting of the columns must be checked. If this does not result in discovery, the separate amounts must be compared with the accounts in the ledger to see that the balances have been correctly brought into the trial balance, both as regards amount and the column in which they have been entered. The casting of the ledger accounts must be checked to ensure that the balances struck are correct. Where an account has been omitted because both sides apparently agree, the castings must be carefully revised, to see if by chance there is really a balance on the account that should be included. If these steps do not

result in the discovery of the difference, a search should be instituted for an item of the same amount as the difference, as it may be that it has been posted to only one side of the ledger; or the difference may be halved and a search made for the resulting amount, as it is possible that an item of that amount has been posted to the wrong side of the ledger. In such an event the effect on the balance of the account will be twice the amount so posted.

Other Measures. If none of the above suggestions results in the difference being found it will probably be best to call over the postings of the books of first entry into the ledgers. This, in the case of a large business, is a work of considerable magnitude, and is usually the last step to which recourse is had. In fact, the labour involved is so heavy that a system has been devised by which, where a large number of ledgers are in use, it is possible to locate an error as being in a particular book, and thus save an immense amount of time in the event of the trial balance of the whole of the ledgers not agreeing. This system is known as *sectional balancing* or *self-balancing ledgers*, and will be explained in detail in a later chapter.

However small the amount of a difference may be, it *must* be traced, as there is always the danger that it represents the balance of two or more errors of large amount, and is not a simple error in itself.

Hints on Posting. One or two hints with regard to the mechanical work of posting, with a view to guarding against errors, will not be out of place here. Care should be taken in forming all figures; fives, eights, and threes should be quite distinct from one another, as should sevens and nines. The tails of the two last-named numbers should not be carried down too low, or they may be mistaken for ones in the line beneath. Do not enter figures too close to the binding. The writer has a lively recollection of a search extending over weeks for an item of fivepence, which was at length discovered almost out of sight in the bound edge of the book. Care must be taken in the pounds column to keep units under units, tens under tens, etc. In banks and other establishments dealing with large amounts, faintly ruled lines are provided in that column in order that the cashiers may strictly and yet easily conform to this rule. Post all debits first, and do not commence posting credits until the debits are exhausted. If it can be arranged, it is better for one clerk to post the debits and another the credits.

Compensating Errors. It was stated on page 1327 that there are certain errors which the trial balance does not disclose. These may be classed generally as compensating errors. They are so called for the reason that they have a twofold effect. They are the more difficult of detection for the very reason that the trial balance does not reveal them, and search cannot, therefore, be made for them at the time of balancing the books, as their existence is not known. They are brought to light by different means, according to their nature. This will be more clearly understood if we deal with specific instances:

(1) INCORRECT CASH-BOOK ENTRY.

An incorrect amount has been entered in the cash book as received from a customer.

This would not affect the balancing of the books, for the incorrect amount entered as received on the debit side of the cash account will also be entered on the credit side of the customer's account. The error will be discovered when counting the cash for the purpose of checking it with the balance of the cash account. If this operation be carried out daily, as dictated by ordinary prudence, the error would not have serious consequences, as it would probably be discovered before the amount had been actually posted to the customer's account.

(2) WRONG AMOUNT OF PURCHASE OR SALE.

Entry of an incorrect amount in the invoice book or purchases journal.

The amount will be posted to the ledger to the credit of the seller of the goods, and would also be included in the total of the purchases for the week or month, as the case might be, and posted to the debit of the goods or purchases account. This, it is clear, would have no effect on the balancing of the ledger, and would not, therefore, be discovered at balancing time. It would not, however, be discovered so quickly as the preceding instance, for, as we have seen, the balance of the goods account does not necessarily, or even probably, agree with the value of the goods in hand. And even if it did this fact would not lead to discovery at once; for stock, unlike cash, is not counted daily or even frequently, but at intervals sometimes of as long as twelve months. The error will probably remain undetected until the monthly statement of account is received from the seller and compared with the ledger account before being passed for payment. A similar error committed in the day book or sales journal would be discovered when rendering the monthly statement to the purchaser, who would promptly repudiate liability if he had been overcharged, and who should, of couse, call attention to the error if he has been undercharged.

(3) POSTED OR ENTERED TO WRONG ACCOUNT.

(*a*) An amount posted to the right side of the wrong account.

(*b*) An amount entered to the wrong account.

Obviously, this will not affect the balancing of the books, as the amount appears on the proper side of the ledger. Suppose it be cash received from Y, but posted to the credit of X. The error will be discovered when sending in a statement of account to the former. He would point out that he had not been credited with the payment, and a reference to the cash book would show that the sum had been erroneously credited to X.

If the error arose in the posting of a sale of goods it would come to light in the same manner by charging the person with goods he had not received. Upon hearing from him that he had not

had the goods, a search would reveal the facts, and the error would be rectified by cancelling the debit to him and debiting the actual purchaser. An error in crediting a purchase to the wrong person would be discovered when comparing statements received for payment with the ledger accounts.

If the name of the wrong person has been given in the book of original entry the effect will be the same as in the cases above cited, for the result will be that the debit or credit will still go to the correct side of the ledger, but to the wrong account.

(4) PURCHASE TREATED AS SALE.

This would be posted to the debit of the customer, then included in the total of sales for the month, and posted to the credit of sales or goods account. The double entry principle having been observed, the balancing of the ledger is not affected. It should not be necessary in such a case as this to wait either for repudiation by the supposed customer charged or for the statement from the person who sold the goods. An intelligent clerk would know from the name and address that, instead of being a buyer, the supposed customer is really a seller, and an inquiry would result in the discovery of the error. Further, in a business of any size, a separate ledger would be kept for the accounts of sellers and another (or several) for those of customers. The fact of a new account being necessary for a familiar name should lead to inquiry and the detection of the mistake.

Danger of Double Errors. Owing to the nature of compensating errors, their detection is not a matter depending upon the correct balancing of the books, but rather upon common-sense and the alertness of the clerks in charge. Careless checking of statements of account or failure on the part of a customer to notify an undercharge will result, in the absence of other means of discovery, in an error of this nature remaining undetected. Too much stress, therefore, cannot be laid upon the necessity of a bookkeeper looking upon himself not as a mere machine for recording whatever is put before him, however improbable, but of using his intelligence and making such inquiries as, from the nature of the transaction, appear desirable, in any case where a doubt is raised of the accuracy of the original entry.

In the next chapter the profit and loss and the balance sheet are dealt with. Meanwhile, students are invited to test their progress by working the following exercises, selected from a Grade II. Bookkeeping Paper set in an examination held by the Society of Arts.

John Shaw, having opened an account with the Dales Bank, Ltd., by paying in £4,200 to his credit, on October 12, 1903, purchased (by cheque) on the following day, the Duchess Slate Quarry from William Black, the purchase price (after valuation) being —Freehold land and quarry, £2,350 ; stock of slates, £300; and machinery, plant, tools, etc, £350. The following were his transactions up to November 21, 1903. All moneys received were paid into the bank, and (except where stated) all payments made by cheque.

1903, Oct. 14. Drew and cashed cheque (for petty cash) for £20.

16. Bought machinery from Gray & Co. for £15. Gave them his acceptance, at one month, which was duly honoured.

19. Sold G Hill 3,500 slates at £7 8s. per 1,000.

Bought 2 cwt. of drills from Sheffield Steel Co., Ltd., at £20 per ton.

21. Paid rates, £6 10s. 4d.

23. Sold Parker & Co. 1,600 slates at £7 4s. 2d. per 1,000.

24. Drew cheque £73 7s. 9d. for wages, and paid the same.

Banked cash received for cartage, £4 2s. 6d.

27. Made G. Hill an allowance for 250 broken slates (invoiced on Oct. 19, 1903), and made a claim upon the railway company for the amount.

28. Received cheque from G. Hill in settlement of his account, less 5 per cent. discount allowed.

Bought 3 tons of rails at £5 a ton from Rotherham Forge Co., Ltd.

29. Sold Parker and Co. 1,500 slates at £7 4s. per 1,000.

31. Sold D. Green 4,200 slates at £8 3s. 4d. per 1,000.

Drew cheque and cashed same (for petty cash) for £11 15s. 4d., the petty cash being kept upon the "imprest" system.

Paid manager's salary for the month, £30.

Drew cheque £68 3s. 7d. for wages, and paid the same.

Nov. 5. Received cheque £10 from Parker and Co. (on account).

Bought oil and other stores from Slippery & Co. for £4 10s.

6. Paid Sharp & Co. cheque £21 for legal charges.

7. Parker & Co's cheque for £10 returned by the bankers dishonoured, the bank charges on same being 1s.

Drew cheque £70 8s. 4d. for wages, and paid the same.

Banked cash received for cartage, £7 14s.

Bought 10 cwt. blasting powder at £5 a ton from Dynamite & Co., Ltd.

10. Received cheque from Parker & Co. for £10 (on account).

16. Bought timber from D. Green for £16.

19. Received cheque from railway company for claim (in full) made Oct. 27, 1903.

21. Drew cheque for self for private purpose £20, and cashed same.

Drew cheque £62 17s. 6d. for wages, and paid the same.

Pass the above transactions through the proper books to the ledger; balance the accounts as on Nov. 21, 1903 ; bring down the balances and extract a trial balance. No profit and loss account or balance sheet to be raised.

NOTE. No particulars being given as to the petty cash cheque for £11 15s. 4d. this amount must be entered in one sum in the main cash book. Wages need not be passed through the petty cash book in this case.

J. F. G. PRICE

SHORTHAND—LESSON 10. BY SIR ISAAC PITMAN & SONS'

TWO abbreviating devices, which are employed with much success in Pitman's Shorthand, are described in this lesson. The first is the systematic omission of medial consonants and the contraction of the outlines for certain long words of frequent occurrence; and the second, which is known as phraseography, consists of the joining of two, three, or more words without lifting the pen.

Contractions. The consonant *p* is omitted between *m* and *t*; thus

pumped, plumped, bumped, tramped,

damped, stamped, thumped, camped.

P between *m* and *sh*; thus

presumption, redemption, assumption.

T between *s* and another consonant; thus

post, postage, postage stamps, post office.

postpone, postponements, most, mostly, honest,

honestly, test, testimony, testimonial, testament.

K or *G* between *ng* and *t* or *sh*; thus

distinct, distinction, distinguish,

anxious, sanction, sanctity.

The following special contractions should be committed to memory.

List of Contractions

Acknowledge-d
altogether
anything
architect-ure-al
Better than
Catholic
character
characteristic
Danger
dangerous
destruction
difficulty
disinterested-ness
doctrine
domestic
Enlarge-d
especial-ly
establish-ed-ment
everything
expect-ed
Govern-ed

government
Immediate
immediately
impossible
impracticable
improbable-bly-ility
influence
influenced
influential
information
instruction
interest-ed
irregular
Knowledge
Manuscript
messenger
mistake-n
more than
Neglect-ed

never
nevertheless
next
nothing
notwithstanding
Object
objection
Parliamentary
peculiar-ity
perform-ed
performance
performer
phonographer
phonographic
practice-d-cal-ly
practicable
probable-bly *or* probability
prospect
public-sh-ed
publication

Rather *or* writer
rather than
reform-ed
reformation
reformer
regular
remarkable-ly
represent-ed
representation
representative
republic
republican
respect-ed
Reverend
Satisfaction
satisfactory
something
stranger
subscribe-d

subscription
surprise
Thankful
together
transcript
transfer
transgress
transgression
Unanimity *or* unanimous
understand
understood
unexpected-ly
uniform-ity
uninfluential
uninteresting
unsatisfactory
Whatever
whenever
Yesterday

Tick *The*. A slanting tick, joined to the preceding character, and usually written downward, is employed to represent *the;* thus

for the, in the, is the, make the, both the.

When it is more convenient, the tick is written upward; thus

from the, above the, before the, said the, on the.

In order to keep *on the* distinct from *I*, the first stroke must be written sloping. The tick *the* must never be used initially.

Phraseography. The phonographic characters for a common phrase, consisting of several words naturally related to each other, are joined together and written without lifting the pen; for example *I shall be,* *we have not.* These groups of joined characters are known as phraseograms, and the employment of this method of writing is styled phraseography. Phraseograms should not be made of words that can only be joined with difficulty, nor should they be too long, or carry the pen too far from the line. The phraseograms in the following table should be copied several times till they can be readily used.

In phraseography *I* is frequently abbreviated by writing the first stroke only, for example represents *I am*, and *I can.*

Generally, the first logogram in a phrase must occupy its proper position, thus *can be,* *you can;* but a logogram written in the first position may be raised or lowered to accommodate it to the following character, thus *I had,* *I see.*

A logogram or phraseogram may be written over or close to a word to express *con-* or *com-;* thus *you will comply,* *I am content.*

There or *their* may be added to a curved full-length logogram by doubling it; thus *for there,* *from their,* *in their,* *if there.*

Phraseograms

I do	he was	and the	with which
I do not / I had not	he may	should be	with them
I did not	he will	should do	when he was
I have	he would	as it is	when it
I think	we are	as it should be	would it
I was	we have	as well as	would be
I shall	we have not	has not	——
I shall be	we have seen	is it	could not
I am	it is	is not	do not / had not
I will	it is not	who have	did not
you can	it is said	who would	for you
you cannot	it should be	who would not	for this
you may	it would be	who would be	for this reason
you must	of course	that is	in which
you must not	of course it is	that you	in this way
you will	to you	that you are	our own
you will be	to him	which you may	so that
you will do	to me	which you will	they will
you are	to them	which cannot	this is
he thinks	and have	with it	
	and it is		

Shorthand concluded

Chain Rule. Unitary Method. Proportional Parts. Percentage. Profit and Loss. Examples and Answers.

RATIO AND PROPORTION

105. The *ratio* of one quantity to another of the same kind is the number of times the first contains the second.

This "number of times" may be either a whole number or a fraction.

Since we use division to find how many times one quantity is contained in another, the ratio of two quantities is expressed thus $\frac{\text{1st Quantity}}{\text{2nd Quantity}}$, or thus, 1st Quantity : 2nd Quantity, the notation in the second case being an abbreviation of 1st Quantity ÷ 2nd Quantity. Hence, we see that to find the ratio of one quantity to another we have simply to express the first as the fraction of the second, exactly as in Art. **92**. The ratio of 3 furlongs to 5 miles is $\frac{3}{40}$, since this is the result we get, on reducing 3 furlongs to the fraction of 5 miles. Evidently, the quantities must be "of the same kind." There is no ratio between 2 tons and 5 sovereigns, for 2 tons cannot be expressed as a fraction of 5 sovereigns.

106. The two quantities which form a ratio are called the *terms* of the ratio. The first term is called the *antecedent*, and the second the *consequent*.

Since the numerator and denominator of a fraction may both be multiplied or both divided by the same quantity, it follows that the terms of a ratio may both be multiplied, or both divided by the same quantity without altering the value of the ratio.

107. Four quantities are said to be in *proportion* when the ratio of the first to the second equals the ratio of the third to the fourth.

Example 1. 2, 3, 12, 18 are in proportion, since $\frac{2}{3} = \frac{12}{18}$.

Example 2. 7 men, 5 men, 3s. 6d. and 2s. 6d. form a proportion. For the ratio of 7 men to 5 men $= \frac{7}{5}$, and the ratio of 3s. 6d. to 2s. 6d. $= \frac{\text{3s. 6d.}}{\text{2s. 6d.}} = \frac{\text{7 sixpences}}{\text{5 sixpences}} = \frac{7}{5}$.

The proportion is expressed by writing the sign ∷ or the sign = between the two ratios.

Thus, 7 men : 5 men ∷ 3s. 6d. : 2s. 6d.
or, 7 men : 5 men = 3s. 6d. : 2s. 6d.

Either expression is read thus: "7 men is to 5 men as 3s. 6d. is to 2s. 6d."

Since the first two terms of a proportion form a ratio, they must be quantities of the same kind. Similarly, the third and fourth terms must be of the same kind.

The first and last terms of a proportion are called the *extremes*, the second and third are called the *means*.

108. In any proportion, the product of the extremes equals the product of the means.

Consider the proportion 21 lb. : 1 cwt. ∷ 1s. : 5s. 4d.

The first ratio is $\frac{\text{21 lb.}}{\text{1 cwt.}} = \frac{21}{112}$. The second ratio is $\frac{\text{1s.}}{\text{5s. 4d.}} = \frac{12}{64}$. The proportion thus states that $\frac{21}{112} = \frac{12}{64}$.

If we now multiply each of these fractions by 112×64, we obtain $21 \times 64 = 112 \times 12$. That is, the product of the extremes equals the product of the means. Any other case can be proved in the same way.

109. The application of proportion to the solution of problems depends entirely on the property just proved; for, by means of it, we can, when we know any three terms of a proportion, find the remaining term.

Example 1. Find the third term of a proportion in which the first, second, and fourth terms are 7, 11, 77.

The product of the first and last terms $= 7 \times 77$.

Hence, the product of the second and third also $= 7 \times 77$. But the second term is 11.

$\therefore$ The third term $= \frac{7 \times 77}{11} = \underline{49}$ *Ans.*

Example 2. Find a fourth proportional to 21 yd., 8 yd., 42s.

The product of the extremes = product of means $= 8 \times 42$.

The first term is 21; therefore the fourth $= \frac{8 \times 42}{21} = 16$; and, since the third term is 42 *shillings* the fourth term = 16s. *Ans.*

110. We shall now solve one or two problems by the aid of proportion.

Example 1. If 1 ton 5 cwt. of coal cost £1 11s. 3d., what will be the cost of 3 tons 5 cwt.?

Explanation. We make our "answer" the fourth term of the proportion. Now, the third and fourth terms must be of the same kind (Art. **107**). Hence, since our fourth term is to be a "cost," so also must our third term. We see, then, that £1 11s. 3d. must be taken for our third term. It only remains for us to determine which of the two other terms, viz., 1 ton 5 cwt. and 3 tons 5 cwt., is the first term and which the second. To do this we ask ourselves the question: "Will 3 tons 5 cwt. cost more or less than 1 ton 5 cwt.?" Evidently, it will cost more; so that the answer we are seeking is greater than £1 11s. 3d.—*i.e.*, the fourth term is greater than the third. It follows that the second term must be greater than the first. Therefore, we are able to *state* our proportion, thus:

1 ton 5 cwt. : 3 tons 5 cwt. ∷ £1 11s. 3d. : Ans.

We must now reduce the first and second terms to the same denomination (since a *ratio* is a *fraction*, and to express one quantity as a fraction of another we must reduce them to terms of the same unit). The answer is then obtained by multiplying together the second and third terms, and dividing by the first (Art. **109**). Since the product of the second and third terms forms the numerator of our answer, and the first term forms the denominator, it is clear that we may cancel common factors of the first and third terms, or of the first and second, but *not* of the second and third.

The work finally appears thus:

1 ton 5 cwt. :	3 tons 5 cwt. ::	£1 11 3 : Ans.
20	20	13
$\cancel{25}$ cwt.	$\cancel{65}$ cwt.	5)20 6 3
5	13	£4 1 3 *Ans.*

Example 2. If a certain pasture lasts 56 sheep 24 days, how long will it last 64 sheep ?

Here, the term which is of the same kind as the required answer is 24 days. Put 24 days for the third term. Next, ask the question " Will 64 sheep be able to graze for a longer or shorter period than 56 sheep ? Evidently, since there are *more* sheep, the pasture will last *less* time. The second term must, therefore, be less than the first.

Hence,

64 sheep : 56 sheep :: 24 days : Ans.

$$\therefore \text{ Ans.} = \frac{\overset{3}{\cancel{24}}\times\overset{7}{\cancel{56}}}{\underset{\cancel{8}}{\cancel{64}}} \text{ days} = \underline{21 \text{ days.}}$$

111. Such questions as the above, in which we are given three quantities and required to find a fourth, belong to *Simple* Proportion. We shall now consider questions of a like nature, but having more quantities involved, and thus requiring more than one application of the rule in order to solve them. Such questions belong to *Compound* Proportion.

Example 1. The carriage of 36 lb. for 45 miles is 6s. 9d. How far will 58 lb. be carried for 14s. 6d. ?

We first consider the following question: " If 36 lb. be carried 45 miles for 6s. 9d., how far will 36 lb. be carried for 14s. 6d. ? " The 36 lb. carried, being the same in each case, cannot affect the question. Therefore, we have 6s. 9d. : 14s. 6d. :: 45 miles : required distance.

$$\text{Hence, this distance} = \frac{45 \times 14\text{s. } 6\text{d.}}{6\text{s. } 9\text{d.}} \text{ miles,}$$
$$= \frac{45 \times 174}{81} \text{ miles.}$$

We next ask, " If 36 lb. be carried $\frac{45 \times 174}{81}$ miles for 14s. 6d. how far will 58 lb. be carried for 14s. 6d." Here, the 14s. 6d. does not affect the question, and we have (since *more* lbs. will be carried a *less* distance),

$$58 \text{ lb.} : 36 \text{ lb.} :: \frac{45 \times 174}{81} \text{ miles} : \text{Ans.}$$

$$\text{Ans.} = \frac{\overset{5}{\cancel{45}}\times\overset{3}{\cancel{174}}\times\overset{4}{\cancel{36}}}{\cancel{81}\times\cancel{58}} \text{ miles} = \underline{60 \text{ miles.}}$$

We see, then, that the given distance, 45 miles, has to be changed in the ratio formed by multiplying together the two ratios $\frac{174}{81}$ and $\frac{36}{58}$.

The ratio formed by multiplying together two or more ratios is called the ratio *compounded* of those ratios.

It may be expressed by writing the separate ratios under one another and bracketing them together.

The above example would then be stated as follows:

$$\left.\begin{array}{l} 6\text{s. } 9\text{d.} : 14\text{s. } 6\text{d.} \\ 58 \text{ lb.} : 36 \text{ lb.} \end{array}\right\} :: 45 \text{ miles} : \text{Ans.}$$

and the answer is obtained by multiplying the third term by all the second terms, and dividing by all the first terms.

Example 2. If 25 men dig a trench 210 yd. long, 4 yd. wide, 2 yd. deep in 315 days of 8 hours each, in how many days will 150 men dig a trench 280 yd. long, 3 yd. wide, and 3 yd. deep, working 10 hours a day ?

First, pick out the quantity which is of the same sort as the required answer, *i.e.*, 315 days. This is our third term. We now ask a series of questions, referring always to this 315 days.

(i) If 25 men take 315 days, how long will 150 men take ? Less. Therefore, first ratio is 150 men : 25 men.

(ii) If 210 yd. length takes 315 days, how long will 280 yd. length take ? More. Therefore, second ratio is 210 yd. : 280 yd.

(iii) If 4 yd. width takes 315 days, how long will 3 yd. width take ? Less. Hence, 4 yd. : 3 yd.

(iv) Similarly, considering the depth, we get 2 yd. : 3 yd., and (v) considering length of day, we get 10 hours : 8 hours. Hence, our statement is,

$$\left.\begin{array}{rcl} 150 \text{ men} & : & 25 \text{ men} \\ 210 \text{ yd.} & : & 280 \text{ yd.} \\ 4 \text{ yd.} & : & 3 \text{ yd.} \\ 2 \text{ yd.} & : & 3 \text{ yd.} \\ 10 \text{ hr.} & : & 8 \text{ hr.} \end{array}\right\} :: 315 \text{ days} : \text{Ans.}$$

∴ Required number of days

$$= \frac{\overset{63}{\cancel{315}}\times\cancel{25}\times\overset{4}{\cancel{280}}\times\cancel{3}\times\cancel{3}\times\cancel{8}}{\underset{\underset{\cancel{2}}{\cancel{6}}}{\cancel{150}}\times\underset{\cancel{3}}{\cancel{210}}\times\cancel{4}\times\cancel{2}\times\underset{\cancel{2}}{\cancel{10}}} = \underline{63 \text{ days } \textit{Ans.}}$$

CHAIN RULE

112. Suppose we have a series of quantities of different kinds, with a given relation between the first and second, between the second and third, and so on. We find the relation between the first quantity and the last quantity by a method known as *Chain Rule*.

Example 1. If 3 turkeys are worth 5 geese, 4 geese are worth 11 ducks, 3 ducks are worth 4 fowls, and a pair of fowls costs 6 shillings, find the value of a turkey.

Using the sign = to denote " are worth," we have

Required value (in shillings)	=	1 turkey.
3 turkeys	=	5 geese.
4 geese	=	11 ducks.
3 ducks	=	4 fowls.
2 fowls	=	6 shillings.

Thus, the same denominations (shillings, turkeys, etc.), occur on the left as occur on the right. Therefore, the product of the *numbers* on the left will equal the product of the *numbers* on the right; from which we obtain

$$\text{Required value} = \frac{1 \times 5 \times 11 \times \cancel{4} \times \cancel{6}}{3 \times \cancel{4} \times \cancel{3} \times \cancel{2}} \text{ shillings}$$

$$= \frac{55}{3} = \underline{18\text{s. } 4\text{d. } Ans.}$$

Example 2. In a mile race A beats B by 66 yd. B beats C by 80 yd. By how much does A beat C ?

Here, A goes 1760 yd. while B goes 1760 − 66, or 1694 yd. B goes 1760 yd. while C goes 1760 − 80, or 1680 yd.

Arranging the work as in Ex. 1, we have

A's 1760 = B's 1694
B's 1760 = C's 1680
Reqd. C's = A's 1760

$$\therefore \text{ C goes } \frac{\overset{77}{\cancel{1694}} \times \overset{21}{\cancel{1680}} \times \cancel{1760}}{\underset{22}{\cancel{1760}} \times \cancel{1760}} \text{ yd.} = 1617 \text{ yd.}$$

$\therefore$ A beats C by 1760 − 1617 = $\underline{143 \text{ yd. } Ans.}$

UNITARY METHOD

113. All the examples considered in Arts. **110–112** may be solved by the *Unitary Method*. Such a method is neat enough when applied to problems in simple proportion, but is not to be recommended in other cases. We shall, however, work out Example 2 of Art. **110**, and Example 1 of Art. **111**, to illustrate it.

Example 2, Art. 110. If a certain pasture lasts 56 sheep for 24 days, how long will it last 64 sheep ?

Pasture lasts 56 sheep for 24 days.

$\therefore$ It lasts 1 sheep for 24×56 days.

$\therefore$ It lasts 64 sheep for

$$\frac{24 \times 56}{64} \text{ days} = \underline{21 \text{ days } Ans.}$$

Example 1, Art. 111. The carriage of 36 lb. for 45 miles is 6s. 9d. How far will 58 lb. be carried for 14s. 6d. ?

For 6s. 9d. 36 lb. is carried 45 miles.

$\therefore$ For 1d. 36 lb. is carried $\frac{45}{81}$ miles.

$\therefore$ For 1d. 1 lb. is carried $\frac{45 \times 36}{81}$ miles.

For 14s. 6d. 1 lb. is carried

$$\frac{45 \times 36 \times 174}{81} \text{ miles.}$$

For 14s. 6d. 58 lbs. is carried

$$\frac{45 \times 36 \times 174}{81 \times 58} \text{ miles} = \underline{60 \text{ miles } Ans.}$$

PROPORTIONAL PARTS

114. It is often required to divide a given quantity into parts proportional to given numbers. The method of working will be understood from the following examples :

Example 1. Divide £8 12s. 6d. into three parts proportional to 2, 3, and 5.

Since 2 + 3 + 5 = 10, it is evident that if we divide the sum of money into 10 equal portions, the three parts required will consist respectively of 2, 3, and 5 of these portions.

Now, £8 12s. 6d. ÷ 10 = 17s. 3d.

$\therefore$ The three parts required are

$$\left.\begin{array}{r} 17\text{s. } 3\text{d.} \times 2 = £1\ 14\text{s. } 6\text{d.} \\ 17\text{s. } 3\text{d.} \times 3 = £2\ 11\text{s. } 9\text{d.} \\ \text{and } 17\text{s. } 3\text{d.} \times 5 = £4\ \ 6\text{s. } 3\text{d.} \end{array}\right\} \underline{Ans.}$$

Example 2. Three men, A, B, and C, rent a field for £24 9s. 2d. A grazes 23 cattle for 17 days, B grazes 27 for 15 days, and C 21 for 18 days. How much of the rent should each pay ?

A's 23 cattle for 17 days require as much as 23 × 17 cattle for 1 day = 391 for 1 day.

Similarly, B uses as much as 27 × 15 = 405 for 1 day.

And C uses as much as 21 × 18 = 378 for 1 day.

The rent should, therefore, be divided in the proportion of 391, 405, and 378.

Now 391 + 405 + 378 = 1174.

Therefore, A should pay

$$\frac{391}{1174} \text{ of } £24\ 9\text{s. } 2\text{d.} = 391 \times \frac{5870\text{d.}}{1174} = 391 \times 5\text{d.}$$

$$\left.\begin{array}{r} = £8\ \ 2\text{s. } 11\text{d.} \\ \text{B should pay } 405 \times 5\text{d.} = £8\ \ 8\text{s. } \ 9\text{d.} \\ \text{C should pay } 378 \times 5\text{d.} = £7\ 17\text{s. } \ 6\text{d.} \end{array}\right\} \underline{Ans.}$$

Example 3. Three boys, A, B, and C, divide 10726 nuts between them. As often as A takes 4, B takes 5, and as often as B takes 3, C takes 7. Find the number each boy has.

A's share : B's share = 4 : 5.
B's share : C's share = 3 : 7.

The numbers representing B's share in the two ratios are 5 and 3. The L.C.M. of 5 and 3 is 15. Therefore, multiply the first ratio by 3 and the second by 5, in order to make B's share be represented by the same number, 15, in each ratio. We thus obtain

A's share : B's : C's = 12 : 15 : 35.

$\therefore$ A has

$$\frac{12}{12 + 15 + 35} \text{ of the nuts} = \frac{12}{62} \text{ of } 10726$$

$$\left.\begin{array}{r} = 12 \times 173 = 2076 \\ \text{B has } 15 \times 173 = 2595 \\ \text{C has } 35 \times 173 = 6055 \end{array}\right\} \underline{Ans.}$$

EXAMPLES 14

1. A man whose stride is 30 in. takes 3120 steps to go a certain distance. How many steps will a man whose stride is 2 in. longer take to go the same distance ?

2. A garrison of 5000 men has provisions for 137 days. After 50 days it is reinforced by 800 men. How many more days will the provisions now last ?

3. A man contracts to do a piece of work in 48 days, and employs 20 men. He finds, at the end of 36 days, that only half the work is finished. How many extra men must he now engage in order to fulfil the contract ?

4. When candles are 6 to the pound, each candle burns 6 hours. How long will a candle burn when they are 8 to the pound ?

5. In a certain village 2 women in every 5, and 4 men in every 9, are unmarried. There are 24 unmarried women, and the total number of men is to the total number of women in the ratio 3 : 4. Find the number of married men.

6. A cask was filled with wine and water mixed together in the ratio 5 : 3. When 16 gallons of the mixture had been drawn off, and water put in instead, the ratio of wine to water was 3 : 5. How many gallons did the cask hold ?

7. If the carriage of 72 cwt. for 15 miles is £2 5s., how far will 5 cwt. be carried for half-a-crown ?

8. If 4 men or 8 women can plant a field of 5 acres in $3\frac{1}{2}$ days, working 10 hours a day, how long will it take 2 men and 3 women to plant 8 acres working 12 hours a day ?

9. The first of 4 boys can copy 4 pages while the second copies 5, the second does 6 while the third does 7, and the third does 3 while the fourth does 2. How many pages will the fourth boy copy while the first boy does 18 pages ?

10. In a 100 yd. race A beats B by 1 yd. B beats C by $1\frac{1}{4}$ yd. in 120 yd. By how much will A beat C in a mile, supposing A, B, and C to always run at the same rates ?

11. A heap of 126 coins consists of half-crowns, florins, and shillings ; the values of the half-crowns, florins, and shillings are as 2 : 3 : 4. How many shillings are there ?

12. If 100 men can make an embankment 55 yd. long, 20 ft. wide, and 5 ft. high in 4 days, working 11 hours a day, how many will be required to make an embankment 120 yd. long, 25 ft. wide, and 4 ft. high, in 5 days, working 12 hours a day ?

PERCENTAGE

115. The expression "per cent.," which is an abbreviation of the Latin words "per centum," means "for each hundred."

The symbol % is often used to denote "per cent." Thus, 7 per cent., or 7%, means 7 parts out of every 100 parts, *i.e.*, $\frac{7}{100}$ of the whole.

The *number* per cent. is called the *rate* per cent.

116. Clearly, then, a percentage of a given quantity can always be expressed as a vulgar fraction of that quantity. In some cases the corresponding vulgar fractions are so simple that it is advisable to remember them. For example:

$$25\% = \frac{25}{100} = \frac{1}{4}, \qquad 50\% = \frac{50}{100} = \frac{1}{2},$$

$$75\% = \frac{75}{100} = \frac{3}{4}, \qquad 33\tfrac{1}{3}\% = \frac{33\frac{1}{3}}{100} = \frac{1}{3},$$

$$66\tfrac{2}{3}\% = \frac{66\frac{2}{3}}{100} = \frac{2}{3}, \qquad 5\% = \frac{5}{100} = \frac{1}{20},$$

$$2\tfrac{1}{2}\% = \frac{2\frac{1}{2}}{100} = \frac{1}{40}, \qquad 12\tfrac{1}{2}\% = \frac{12\frac{1}{2}}{100} = \frac{1}{8},$$

and so on.

Again, since $5\% = \frac{1}{20}$, 5% of £1 = 1s. Therefore, 5 per cent. of any sum of money is "1s. in the £." Similarly, $2\frac{1}{2}$ per cent. of a sum of money is "6d. in the £."

117. To find any required percentage of a given quantity, express the percentage as a vulgar fraction, and take that fraction of the given quantity.

Example 1. Find the value of 7 per cent. of 35 tons.

7 per cent. $= \frac{7}{100}$.

Hence

$$\begin{array}{r} 35 \text{ tons} \\ 7 \\ \hline 2{\cdot}45 \text{ tons} \\ 20 \\ \hline 9{\cdot}00 \text{ cwt.} \\ \hline \end{array}$$

2 tons 9 cwt. *Ans.*

Conversely, to find what percentage one quantity is of another, reduce the first quantity to the fraction of the second [Art. **92**]. and take that fraction of 100.

Example 2. A tradesman deducts 3*s*. 6*d*. from an account for £5 16s. 8d. as "discount for cash." What rate per cent. does he allow ?

$$\text{Required rate per cent} = \frac{3\text{s. } 6\text{d.}}{£5\ 16\text{s. } 8\text{d.}} \text{ of } 100$$

$$= \frac{42}{1400} \text{ of } 100 = 3\% \ \textit{Ans.}$$

PROFIT AND LOSS

118. When a thing is sold for more than it cost the seller, it is said to be sold at a *profit*. If it is sold for less than the cost, it is sold at a *loss*. Hence,

Profit = Selling Price − Cost Price.
Loss = Cost Price − Selling Price.

A profit, or loss, is generally reckoned as a percentage.

It is always understood that *the percentage is reckoned on the cost price.*

Thus, if an article which costs 9*d*. is sold for 1s., the seller gains 3d. on an outlay of 9d., *i.e.*, he gains $\frac{3}{9}$, or $\frac{1}{3}$ of his outlay. His gain per cent. is, therefore, $\frac{1}{3}$ of 100, or $33\frac{1}{3}$ per cent.

A common mistake is to say that he gains 3d. on 1s., *i.e.*, $\frac{1}{4}$ of 100 per cent., or 25 per cent.

119. The types of questions met with in Profit and Loss, and the methods of solving them, will be understood from the following examples :

Example 1. A merchant buys 56 gallons of wine for £58 6s. 8d., and sells it at 21s. 8d. a gallon. What is his gain or loss per cent. ?

$$\text{He buys 1 gallon for } \frac{£58\ 6\text{s. } 8\text{d.}}{56} = £1\ 0\text{s. } 10\text{d.}$$

He sells 1 gallon for £1 1s. 8d.

Therefore, he gains £1 1s. 8d. − £1 0s. 10d., *i.e.*, 10d., on an outlay of £1 0s. 10d., or 250d.

His gain per cent. is, therefore,

$\frac{10}{250}$ of $100 = 4\%$ *Ans.*

Example 2. A watch was sold for £8 11*s*. at a loss of 5 per cent. What would have been the gain or loss per cent. had it been sold for 10 guineas ?

The watch is sold for 95 per cent. of its cost. We have, then, a question in simple proportion, viz., "If £8 11s. represents 95 per cent. of the cost, how much per cent. of the cost does £10 10s. represent ? " Whence,

£8 11s. : £10 10s. :: 95% of cost : required percentage.

$$\therefore \text{ Ten guineas represents } \frac{\overset{5}{\cancel{95}} \times \overset{70}{\cancel{210}}}{\underset{\underset{3}{\cancel{9}}}{\cancel{171}}} \text{ per cent. of cost}$$

$= \frac{350}{3} = 116\frac{2}{3}$ per cent. of cost, *i.e.*, there is a *gain* of $16\frac{2}{3}\%$ *Ans.*

Note that in questions like **Ex. 2** it is not necessary to find the cost price.

Example **3**. A jeweller prices a brooch 40 per cent. above cost. He deducts $12\frac{1}{2}$ per cent. for cash, and gains 9s. What did the brooch cost him ?

A brooch which costs 100 is marked 140, *i.e.*, it is marked at $\frac{140}{100}$, or $\frac{7}{5}$ of its cost.

The jeweller deducts $\frac{12\frac{1}{2}}{100}$ of its marked price, so that he sells it for $\frac{87\frac{1}{2}}{100}$, or $\frac{7}{8}$ of its marked price.

But $\frac{7}{8}$ of marked price $= \frac{7}{8}$ of $\frac{7}{5}$ of cost $= \frac{49}{40}$ of cost $= (1 + \frac{9}{40})$ of cost.

He therefore gains $\frac{9}{40}$ of what it cost him.

Hence, 9s. $= \frac{9}{40}$ of cost.

Therefore, cost = 40s. = £2 *Ans.*

Example **4**. If $2\frac{1}{2}$ per cent. more is gained by selling a horse for £75 than by selling it for £73 10s., what did the horse cost ?

The difference in the selling prices = £75 − £73 10s. = £1 10s.

Therefore £1 10s. is $2\frac{1}{2}$ per cent. of the cost price, *i.e.*, $\frac{1}{40}$ of the cost price.

Hence, cost price = 40 × £1 10s. = £60 *Ans.*

Example **5**. A man sells an article at a profit of 5 per cent. Had he bought it $6\frac{1}{4}$ per cent. cheaper and sold it for 9d. more than he did, he would have gained 15 per cent. Find the cost price.

If he bought for $6\frac{1}{4}$ per cent. less, he would pay $\frac{93\frac{3}{4}}{100}$ of what he actually does pay.

To gain 15 per cent. he must sell for $\frac{115}{100}$ of the cost, *i.e.*, he must sell for $\frac{115}{100} \times \frac{93\frac{3}{4}}{100}$ of the actual cost.

$$= \frac{\overset{23}{\cancel{115}}}{\underset{\underset{4}{\cancel{20}}}{\cancel{100}}} \times \frac{\overset{\overset{3}{\cancel{15}}}{\cancel{375}}}{\underset{16}{\cancel{400}}} = \frac{69}{64} \text{ of actual cost.}$$

But he really sells to gain 5 per cent., *i.e.*, for $\frac{105}{100}$, or $\frac{21}{20}$ of the cost price. The difference between these selling prices is $(\frac{69}{64} - \frac{21}{20})$ of the cost price, or $\frac{345-336}{320} = \frac{9}{320}$ of cost price.

And the question tells us the difference in the selling prices is 9d. Hence, 9d. $= \frac{9}{320}$ of cost price, so that the cost price

= 320d. = £1 6s. 8d. *Ans.*

EXAMPLES 15

1. By selling goods for £247 a merchant loses 5 per cent. What ought the selling price to be to gain 7 per cent. ?

2. A man buys a number of oranges at 2 a 1d. and an equal number at 3 for 2d. He sells the whole at 5 for 3d. Find his gain or loss per cent.

3. If 4 per cent. more is lost by selling an article for 9s. 2d. than by selling it for 9s. 7d., how much per cent. is lost in each case ?

4. A shopkeeper bought 750 eggs at 15 a shilling. He broke 113, and after selling the remainder, found that he had lost 2% on his outlay. How many did he sell for a shilling ?

5. 24 lb. of tea worth 1s. 10d. per lb. are mixed with 8 lb. worth 2s. 10d. per lb. At what price per lb. must the mixture be sold in order to make a profit of 10 per cent. ?

6. A man sold a house at a profit of 10 per cent. Had he sold it for £168 less, and bought it 5 per cent. cheaper, he would have gained 4 per cent. For what amount did he sell the house ?

ANSWERS TO EXAMPLES 14.

1. 2925; **2.** 75; **3.** 40; **4.** $4\frac{1}{2}$ hrs.

5. $\frac{3}{5}$ of the women are unmarried, *i.e.*, $24 = \frac{2}{5}$ of the women. ∴ Total number of women $= \frac{5}{2}$ of 24 = 60. Now, number of men : number of women :: 3 : 4. Hence, number of men $= \frac{3}{4}$ of 60 = 45. But 5 men in every 9 are married. ∴ Number of married men $= \frac{5}{9}$ of 45 = 25 *Ans.*

6. At first $\frac{5}{8}$ of the cask is wine. At the finish $\frac{3}{8}$ of the cask is wine. Therefore the 16 gallons of the mixture taken out contained $\frac{1}{4}$ of a cask of wine. But 16 gallons of the mixture contains $\frac{5}{8}$ of the 16 gallons or 10 gallons of wine. Therefore $\frac{1}{4}$ of a cask is 10 gallons. The cask, therefore, held 40 gallons. *Ans.*

7. Statement is

$$\left.\begin{matrix} 5 : 72 \\ £2\ 5s. : 2s.\ 6d. \end{matrix}\right\} :: 15 \text{ miles} : \text{Ans.}$$

Whence, *Ans.* = 12 miles.

8. 4 men do as much as 8 women. ∴ 1 man = 2 women. Hence, 2 men and 3 women = 7 women. We then have the statement

$$\left.\begin{matrix} 7 \text{ women} : 8 \text{ women} \\ 5 \text{ ac.} \quad 8 \text{ ac.} \\ 12 \text{ hr.} : 10 \text{ hr.} \end{matrix}\right\} :: 3\tfrac{1}{2} \text{ days} : \text{Ans.}$$

Whence, *Ans.* = $5\frac{1}{3}$ days.

9. Calling the boys A, B, C, D, we have

A's 4 pages = B's 5 pages
B's 6 ,, = C's 7 ,,
C's 3 ,, = D's 2 ,,
Reqd. D's = A's 18

Hence,

$$Ans. = \frac{5 \times 7 \times 2 \times 18}{4 \times 6 \times 3} = 17\tfrac{1}{2} \text{ pages.}$$

10. As in Art. **112**, Ex. **2**, we have

A's 100 = B's 99
B's 120 = C's $118\frac{3}{4}$
Reqd. C's = A's 1760

Therefore, while A goes 1 mile, C goes

$$\frac{99 \times 118\frac{3}{4} \times 1760}{100 \times 120} \text{ yd.} = 1724\tfrac{1}{4} \text{ yd.}$$

Therefore, A beats C by $1760 - 1724\frac{1}{4} = 35\frac{3}{4}$ yd. *Ans.*

11. The *values* are as 2 : 3 : 4, which is the same thing as £2 : £3 : £4. Now £2 = 16 half-crowns, £3 = 30 florins, £4 = 80 shillings. Therefore, the *numbers* of the coins are as 16 : 30 : 80. We have, then, to divide 126 coins proportionately to 16, 30, 80. But 16 + 30 + 80 = 126. Hence, the heap contains 80 shillings *Ans.*

12. 160 men.

H. J. ALLPORT

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Estate Agency. Management of a Great Estate.
Church. How to Enter the Ministry of all Denominations.
Scholastic. Teachers. Professors. Governesses. Tutors.
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A WONDERFUL SCULPTURE, CENTURIES OLD

DONATELLO'S FAMOUS BAS-RELIEF OF ST. CECILIA

FACING PAGE 1346

The Pursuit of Knowledge for its own Sake. How Nothing is ever Learned in Vain.

THE SUCCESSFUL STUDENT

When interviewed about the performance of one of his translations of Euripides, Dr. Gilbert Murray said that Greek plays do not appeal to the man-in-the-street, but are liked by working men. What Murray meant is that a thoughtful working man is more receptive of austere poetry than the average man of the well-to-do classes, and that such a fact is noticeable in a modern theatrical audience. That there is the man-in-the-street element in the working class, as in other classes, he would certainly not deny. Happily, it is singularly absent in the leaders of working-class opinion. Times have changed since Cobbett rose in the House of Commons to oppose a grant to the British Museum in the following terms:

> When was the British Museum of the slightest use to the country at large? Last year there was £1000 paid for a collection of insects. What use could that collection be to the weavers of Lancashire, or to farmers and tradesmen in a distant part of the country? The plain fact was that the British Museum was of no use at all. It was a place to which curious people went to entertain themselves by gratifying their curiosity, and in which the rich were accustomed to lounge away their time at the expense of their poorer countrymen. For his own part he didn't know where the British Museum was (much laughter), and was not acquainted with its contents. He thought the sum of £16,000 granted by the Committee was £16,000 thrown away for the gratification of a set of loungers, who had first taken care to get enough out of the taxes to enable them to lounge away the rest of their lives in complete idleness.

We hear nothing like this today, when labour leaders are discussing advanced education. It is the extreme men who claim universal education up to a university standard, and the more moderate spirits who plead the practical side of things. None the less, even though we no longer hear jibes at the love of knowledge from the leaders of public opinion, no matter what section of society we belong to, there is a certain elemental part in most of us that answers to the matter-of-fact man-in-the-street, and rebels against the claims of learning.

The world and its successes seem at those moments to be far removed from the Museum and the Library. We refuse to bow to the point of view represented by Pascal that it is thought that matters, not action; that the greatest things of the world have been done when men were content to sit still in their studies. Is this really true, or, as the man-in-the-street in us would whisper, is the pursuit of knowledge for its own sake a useless, if harmless, fad?

In regard to physical science the case is clear, and the man-in-the-street would soon surrender. It is obvious that the material progress of the world is due to scientific discovery, which must have involved laborious and ungrudging theoretical work. What is not so obvious is that this work has been often, perhaps generally, undertaken without expectation of material reward; and, further, that the work would not have been fruitful if such expectation had been dominant. Faraday gave up the chance of making a large fortune on business lines in order that he might have time and freedom to work out quietly his great theories. He remained a poor man all his life, but he invented the dynamo. It was as a theorist that Clerk-Maxwell, first at King's College, London, and then at Cambridge, worked out that electromagnetic idea of light on which Marconi and other practical men have founded wireless telegraphy. The theory of evolution, which has had so profound an influence on every aspect of modern life, was due to Darwin's patient searching after truth.

"On my return home," he wrote in the "Origin of Species," "it occurred to me, in 1837, that something might perhaps be done by patiently accumulating and reflecting on all sorts of facts which could possibly have any bearing on the origin of species. After five years' work I allowed myself to speculate on the subject and drew up some short notes." The date is significant when we remember that Darwin's famous paper before the Linnæan Society, in which the theory was brought out, was not till 1858, and that the "Origin of Species" was only published in 1859.

It has been said that it is the absence of this disinterested theoretical spirit which is the reason why America, with all its keen attention to science, has not made discoveries that are fundamental in the same way as England, or France, or Germany. American scientists have an eye to immediate profit, to turning their science to some account; and the result is that their work is mainly secondary and subsidiary, however brilliantly practical it may be.

It is certainly less obvious that, on the side of what are called the Humanities, Literature, and History, Philology and Philosophy, the great practical movements of the world, are due to men sitting still in their studies. Yet what more vital movements, with their effect still dominant in our lives today, than the Reformation and the French Revolution? And what could be more abstract and unpractical than the beginnings of both these movements? The French Revolution was due, more than to any one thing, to the writing of Jean Jacques Rousseau, and it was from his theoretic work that there came the blood and fire and joy that transformed the face of Europe. The Reformation, too, was merely one side of the Renaissance, and Robert Browning, with his dramatic insight, has shown in his "Grammarian's Funeral," how startlingly unpractical that revival was.

A man has died whom young Italy, and the young world which has flocked to Italy, loves to honour, and the students hymn him as they bear him to the top of the hill, which is the fit place for the grave of such a man.

This is our master, famous, calm, and dead,
Borne on our shoulders.

And the man who is their hero is no warrior or statesman. He is not even painter, or poet, or sculptor, or musician, to whom the man-in-the-street would, grudgingly enough, allow some place. He is the humblest, the driest, the least obvious of all the kinds of men who sit in their studies; a grammarian, who has done himself to death studying Greek particles. It was work like that which had lit up his life with splendour, so that to his pupils

He was a man born with thy face and throat,
Lyric Apollo.

Browning puts a challenge to us in its extreme form. "That is the type of man," he stoutly asserts "who is the pioneer of civilisation."

Take, again, a more modern instance—the rise of Japan, which has startled us so during the last few decades. The first sign of it, and the leading cause of it, was the enthusiasm for knowledge which possessed the younger generation of Japanese in the middle of last century. It was the "Dutch Scholars," as they were called, who were the pioneers in the opening up of Japan to a knowledge of the outer world. In the memorial which the Conservative Party presented to the Government in 1853, they are expressly mentioned as the force that made for innovation. And those Dutch Scholars were the men who, often at the danger of their own lives, and by infinitely laborious drudgery, fought their way to Western knowledge as it came to them, secretly and in a practically unknown tongue, through the Dutch trading station at Deshima.

What is important to remember is that many of the things best worth doing do not show their value while they are being done. In the division of labour system in industry, different parts of a machine are made by different sets of workmen. Even a pin is never made from start to finish by one man. It is true that a just criticism on the unintelligent way in which this is often managed is that a workman is never taught to see the meaning of his particular piece of work, and how the lifeless little part he is making fits in to a vital and coherent whole.

A great deal might be done in industry to enable the workman to feel that he is a co-partner in the fulfilment of a great purpose. But the intellectual worker will naturally move with his eyes open, and run no such risk. However meaningless his task may seem for the moment, he will be conscious that he is creating knowledge which may be vital for some higher synthesis. This synthesis may be for him, or may be for another, and the excitement of intellectual work largely lies in the uncertainty. What is certain is that good bricks have to be made. The maker cannot tell whether he will be the man to see the place where they fit into the building. It is a hard lesson to learn, even for advanced scholars who ought to know better, that no discovery should be unrecorded merely because the discoverer does not see its importance. Ancient marble inscriptions, for instance, have

been for generations recorded by archæologists, even though they consist of a single word or a fragment of a word.

It has been long recognised that another fragment of the same inscription might be found into which any bit might fit, or that, even if this did not happen, a similar but more perfect discovery elsewhere might give the fragment some quite unexpected significance. The travels of the Roman Emperor Hadrian through the provinces of his empire have thus been ingeniously pieced together by a number of inscriptions, in themselves often fragmentary and insignificant, that seem to have been set up to mark his progress.

Oddly enough, however, scholars who would have thought it sacrilege not to publish in full a marble inscription, felt till lately no such qualms about an inscription on a terra-cotta vase. The English excavators of the old Greek trading station of Naukratis, in the Delta of Egypt, found masses of vase inscriptions that only consisted of a few letters each. At the time, little attention had been given to these vase inscriptions, and the excavators, from sheer want of imagination, regarded them, in their own words, as "unintelligible," and thought they could "hardly be used for any scientific purpose."

Nemesis came in the shape of a well-worked-out and interesting German theory, that many of these vase inscriptions were of a mercantile character, representing private trade-marks or memoranda of sale or purchase. The Naukratis collection, which was unusually large, would have been a god-send for the testing of such a theory, if it had been published in full detail. As it was, it was useless. Such amateurishness would not have been possible if vases had not themselves been regarded at that time as unimportant unless ornamented with beautiful designs.

The excavators of Abæ, in Phocis—again, alas! English—opened a number of ancient tombs rich in vases and figurines, but could find nothing to say about them, except that they were "full of objects of little archæological value"! This pathetic and humilitating piece of self-condemnation can be found in a learned journal of less than twenty years ago.

It requires faith to carry out this principle consistently. When the present writer and Professor Ure were publishing the contents of the graves they had discovered at Rhitsóna, in Bœotia, they were criticised for their rigorous insistence on cleaning and repairing and exhibiting plain and common vases. It took time and money; and what could they prove? For the moment it was indeed difficult to see, and it was on principle that the excavators held to their point, and not from any expectation that they would be as dramatically justified as, in fact, they were. For what the event proved was that simple black drinking-cups, which at first sight looked exactly the same, showed, when carefully studied, a gradual development of shape. The conventional floral design on the round little oil-flasks—with the narrow hole at the top, and the broad, flat rim that prevents the oil from coming out too quickly—are seen to show very similar variations.

If, indeed, there had been only a few of these vases discovered, no sound conclusions could have been drawn from them. But when there were hundreds of them, and the environment in which each type was buried was accurately recorded, they became an important, and indeed a decisive, factor in fixing the dates of the graves. It could be no accident that in one set of graves hundreds of these vases were found in which the four petals of the design were connected at the bottom by an ornament that looks something like a Highlander's kilt; and that in another set the kilt was replaced by a fifth petal. When a third set was discovered in which this curious little change of fashion was in the making, and the two sets balanced, and when this result could be checked by a parallel change in the shape of black cups, a good deal had been done to fix the chronology of some fifty years.

We might take our illustrations, again, from Philology, the study of language. Dictionaries from one language into another our man-in-the-street might admit the use of; but what of dictionaries of our own language, or, what surely must be most barren of all, "concordances" of all the uses of particular words in a given author? Yet even the concordance produces results of general interest. Then, though the New Testament is less than one third as long as the Old, the words "love" and "free," in their various forms, occur more frequently in the New; whereas "anger," "hate," and "wrath" occur six times more often in the Old. It is interesting, again, to find in Wordsworth an absence of words that have low and

mean associations. "Good," "happy," "joy," "hope," "love," occur over 2000 times; "ugly," "bad," "evil," "miserable," "wretched," "anger," "hate," "envy," "suspicion," mount altogether to a total of about 250.

These results, indeed, only serve to bear out our general impressions. It is more illuminating to find that in Wordsworth and the Romanticist school as a whole there is hardly any use of the word "people." Shelley, Burns, and Wordsworth were apostles of freedom, but it was the individual they thought of, not the nation. "People" is commonest of all in the Old Testament, with its conception of Theocracy, the Divine government of the chosen nation. Half of Shakespeare's uses of the word are in his Roman plays, where we are dealing with another civilisation which considers the nation as more important than the individual. The word occurs twice as often in "Coriolanus" alone as in all the ten English historical plays put together. The idea of the people does not bulk large in English literature—or, if we are to draw our inference, in English life—till the second half of the nineteenth century, when Tennyson's frequent use of the word heralds the rise of the Socialistic spirit.

Another study that is supposed to be reserved for Dryasdusts is the comparison of the various manuscripts and editions of an author, sometimes called the science of textual criticism. This naturally finds most play in the case of ancient authors, where the manuscripts have come down to us in a corrupt state, or contradict each other. Few tasks involve more drudgery and minute care, and the results are not often so sensational as in the case of Homer, where they throw light on that most fascinating of problems, the authorship of the first work of European literature; or, as theologians find them in the Greek Testament, where they are the weapon for defence or attack of more than one Christian doctrine. Yet they always train taste and judgment, which can be applied to other and more modern literature. It was left to a great Greek scholar, Dr. Verrall, to expose the numerous printers' errors which disfigure Jane Austen's novels, from the first edition to the last. His emendation of "derelict" for "direct," in Chapter XXIV. of "Mansfield Park," where William is coming back, long overdue, from his voyages, makes sense out of an unintelligible sentence, which Miss Austen herself must have let pass in her proof correcting, that "His direct holidays might with justice be instantly given to the sister, who had been his best correspondent through a period of seven years."

It will be stimulating and comforting, too, to young people to study the various versions of great poems, showing not only the fact that the file had to be used, but often the way in which the mind moved to get the phrasing which to the reader appears so inevitable and direct. "The Blessed Damozel," of Rossetti, if any poem, strikes us as an inspiration, thrown off at white-heat in a moment of tense feeling. The two wonderful lines:

> Her eyes were deeper than the depth
> Of waters stilled at even

were surely written as they stand, once for all. Yet on investigation we find that there were two previous versions, and that the beautiful touch "at even" was an after-thought, suggested by a very unhappy "padding" use of the preposition "even" to rhyme with "heaven" in the preceding couplet. The lines, as they were first published, read:

> Her blue, grave eyes were deeper much
> Than a deep water even.

And even when the last line got its ultimate form, the first was still imperfect. Thus:

> Her eyes knew more of rest and shade
> Than waters stilled at even.

It is not, of course, every quest of knowledge that develops taste. That depends on the subject matter of the knowledge sought. Yet it is true that there are qualities that follow in the train of all true learning. Not only, as we have already seen, is the pursuit of knowledge a great calling, to which the world owes more than it realises, but the pursuer gains for himself on his journeying. Method is in its essentials the same in all intellectual occupations, and to have learnt method is to possess the surest of all tools for life.

We learn method by very carefully observing the way great men before us approached problems, faced difficulties, balanced evidence. "Do not imagine," said Harnack to his students, "that you

can gather knowledge without mental contact with the personalities to whom we owe knowledge, and without studying the road along which they travelled. No scientific knowledge of the higher sort consists of mere facts. Every fact has been experienced, and in this experience has its educational value. Those who content themselves with appropriating results may be compared with a gardener who plants his garden with cut flowers."

It is by such observation—by noticing Darwin, who studied most carefully those passages which seemed to contradict his theories; or Stubbs, who confessed that he had often spent a fortnight in the British Museum to verify one reference; or Fustel de Coulanges, who warns us that to verify quotations is one thing and to read books quite another, and that the two often lead to opposite results—it is thus that we learn how to handle problems ourselves, and, what is quite as important, to estimate the value of other people's handling of them. We learn the necessity, and the difficulty, of strict accuracy, not only for those who, like Froude, have a constitutional inability to state a thing exactly, a mental colour-blindness, but even for conscientious and careful workers like Ruskin, who, when copying a short eight-line inscription over a tomb in the church of Santa Croce, at Florence, managed to mis-spell one word and omit two. We not only learn who are the authorities to be trusted in our own subject, but acquire a sixth sense—a "flair," as the French say—for an authority on any subject.

To know where knowledge is, is next best to possessing it. It is the man who has studied some intellectual subject deeply who is the useful member of a committee when an appointment has to be made, and the few testimonials that count have to be sifted from the numbers that are worthless. It is the man who has studied who knows what evidence is, and, whether it be in politics or business, sees through the superficial and discounts clap-trap. And this contempt of clap-trap, which is half a moral quality, leads on to others that are not merely intellectual. It is difficult for one who has realised the vastness of the field in any department of human knowledge to be as conceited or as dogmatic as most people are; it is like another thing which contrives to keep men humble—living in direct touch with Nature.

There is, at least, a chance too that such a man will be less prejudiced, less at the mercy of his own environment. "We forgive whatever we really understand." Subjectivity is hard to eliminate, and, as Sir Thomas Browne well said, morality is not ambulatory. Yet it is a supreme gift to realise what is unessential in our own prejudices; to admit, in fact, that the unpleasant word is applicable to ourselves. No one but a learned man could have answered as Liddon did, when asked, in its early days, whether he liked the Salvation Army. "No," he said; "I do not. But I expect that God does."

But does this broadmindedness bring with it impotence for action? Will our student become a Mr. Facing-both-ways, seeing both sides of the question so vividly that he can never give his support to either? Will a working man who devotes himself to the Workers' Educational Association grow lukewarm in his trade union or his political organisation? Can we be students and at the same time good reformers, good Churchmen or Free Churchmen—in short, good party men?

It is true that at times of crisis the man with the academic mind will seldom win the loudest cheers from the man-in-the-street on his own side. He will not utter the clap-trap nor use the clever but unfair arguments that appear to be so telling. But a deeper insight shows that even at these moments such things are rather stimulants for those who are already partisans than effective to convert the man who doubts.

What is the real obstacle to a cause? The stupidity of its supporters. It has been said that "no man writes himself down but himself." No cause, we may add, loses but from its own lack of brains. And in the long, quiet times, when policy is being shaped and new ideas and old shibboleths are being weighed in the balance, ours will be the vivifying influence in our Church or party, and we shall be the true practical reformers, if we care neither for tradition nor convention when they conflict with truth, and if, in Plato's words, wheresoever the argument takes us, like a breeze, that way—and no other way—we go.

RONALD M. BURROWS

Leading Characteristics of Norway and Sweden. The Midnight Sun. Sweden Contrasted with Norway. Denmark and Iceland.

THE SCANDINAVIAN KINGDOMS

NORWAY

PARALLEL to our shores, 400 or 500 miles to the east, lie the Scandinavian kingdoms of Norway and Sweden (forming the peninsula of Scandinavia), and Denmark, formed of the peninsula of Jutland, running north from the mainland of Central Europe, and of many islands. They almost separate the North Sea from the Baltic Sea, which is entered from the west by the Skagerrack, Kattegat, and Sound, as already described. Our shores early offered a prize to the pirates of these northern lands, who also occupied the valley of the Seine in France, and, becoming known as Normans, conquered our country in 1066. Our own blood, therefore, is largely mixed with Scandinavian.

Characteristics of Norway. Norway (124,000 sq. miles) occupies the western and steeper slope of the Scandinavian plateau, rising to over 8,000 ft. Except on the lower slopes, it is a treeless moorland, covered with heather, lichens, or reindeer moss. The peaks rise above the snow-line, and the higher valleys are filled with glaciers. The rivers, which often form magnificent waterfalls, descend as swift torrents to the sea. The lower ends of the valleys have been drowned, forming a fringe of rocky islands called the Skerry Guard, the dangerous currents between which gave rise to stories of maelstroms and whirlpools, and fjords [63, p. 813] like those of the Scottish Highlands, but far longer, and enclosed between mountain walls thousands of feet high. These fjords are visited by thousands of tourists every year. The Sogne Fjord, over 100 miles long, one of the most beautiful, has been thus described: "At one moment the boat is beneath a huge cliff that seems to block the narrow channel; at another she is sailing over a clear space, out of which open a number of rocky side fjords. At one moment the view is limited to a few hundred yards of water, bounded on every hand by stupendous precipices; at another the eye ranges up a beautiful valley, or through some depression in the fjord wall catches distant sunlit peeps of glacier or of mountain outlines."

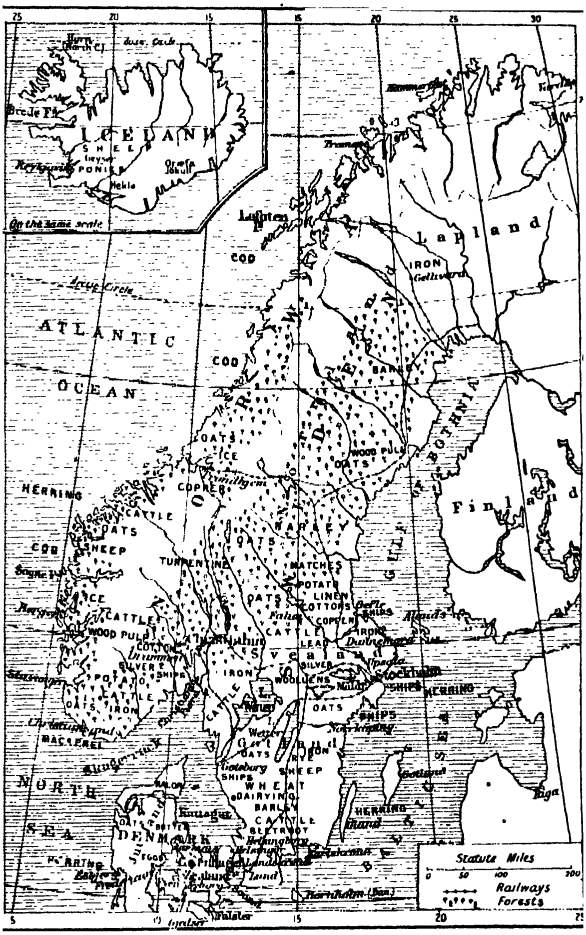
Many waterfalls leap over the fjord walls, adding to the beauty of the scene. High up on the cliffs are seen little farms, where it is said both animals and children have to be tethered.

Climate. Norway extends from the latitude of 58° North to just within the Arctic Circle, giving a considerable difference of temperature between the north and south. Its western shores are washed by the Atlantic, and its prevailing winds, like our own, are south-westerly. As in our own land, these make the winter much milder than it would otherwise be. Norway is a country of considerable elevation, and the high altitude tends to lower the temperature; but the waters of the surrounding seas and the winds blowing over them are warmed by the surface drift from the Gulf Stream, and its ports are therefore ice-free in winter. The climate of the south resembles that of Northern Scotland, with mild winters and cool summers, but in the high interior, and as we go north, the winter becomes very severe, and the land is buried in snow for many weeks. These, however, are almost uninhabited regions, and on the coast, where most of the people live, the winter is less severe than in many more southern parts of Europe. The summer is nowhere hot. Rain, as we should expect, is abundant, especially in winter, when the Atlantic winds have their greatest force.

Land of the Midnight Sun. In our own country we know how late the sun rises in winter, and how early it sets. In Norway, which lies almost wholly north of our islands, this is much more marked. The winter days are everywhere short, and as we go north they are reduced to little more than an hour or two of twilight. The compensation comes in summer, when each day the sun rises higher and remains longer above the horizon. Night becomes merely a short twilight, and in the far north the splendid spectacle of the midnight sun is seen. A traveller writes: "After leaving Hammerfest, we were all on deck to witness sunset and sunrise, if thus it can be termed. It was about 11 p.m. The effect of the sunlight on the headlands was wonderfully beautiful, for as the sun sank lower their tints kept changing, till at last they seemed to be bathed in a vermilion hue. It was now midnight. In a few minutes we noticed the sun gradually rising higher and higher, and now the colours were of a totally different hue. Day had succeeded night almost imperceptibly." With almost continuous sunlight, vegetation comes on as if by magic, and sowing and reaping succeed each other in a few weeks.

A Nation of Seamen. In the high interior the forests of the lower slopes make the cutting of timber and the gathering of turpentine important. Above the tree-line are mountain pastures, to which the cattle are driven in summer. Only the coast is thickly peopled. As in the West Highlands of Scotland, farming is eked out by fishing, which is extremely important. The Norwegians are a nation of seamen. The forest timber has always made the building of boats an easy matter, and the fjords are natural roads from the desolate interior to the sea, with its teeming waters and rich lands beyond. Anciently pirates, the Norwegians now do an immense carrying trade in all parts

of the world. One of the great fishing centres is the Lofoden Islands, in the north, where millions of codfish are caught and dried annually; then the reeking livers are stewed in huge boilers for cod-liver oil. The season begins in January, and lasts till April. For the next two months the fish are left to dry in the summer sun, and the fishing fleet returns for the spoil in June. The whale and seal fisheries are also important. In a word, it is to the sea, not to the land, that the Norwegian looks for a living. Of the land three-fourths is unproductive, over one-fifth forest, and less than one-thirty-third cultivated.



SCANDINAVIAN KINGDOMS, SHOWING CHIEF INDUSTRIES

Towns of Norway. In such a country the towns are, of course, all on the coast. In the south, on Christiania Fjord, is Christiania, the capital, at the end of an ocean avenue fringed with pines and walled with mountains. Farther east, the Glommen, the longest river of Norway, flows to the Skagerrack. Look out on the map Drammen, Stavanger, Bergen, Christiansand, the old city of Trondhjem, Narvik, formerly Victoria Haven, the terminus of a line across the mountains from Gellivara in Sweden, Hammerfest, and Vardö, all fishing ports, finely situated on fjords.

SWEDEN

Sweden (nearly 173,000 sq. miles) is the gentle eastern slope of the Scandinavian plateau. In the north the province of Norrland occupies half of the country. It is "a land of very short summers and very long winters, of high mountains, and great rivers which run in almost parallel lines to the sea, forming navigable waterways to the coast 200 and 300 miles long, a land of great primeval forests and swampy wildernesses, of vast timber and mining industries." Svealand, the midland province, is "the region of great lakes and smiling pasture lands, of well-tilled fields and well-to-do peasant homesteads, of prosperous towns and flourishing industrial enterprises." Götland, in the south, is the richest part of Sweden. "The ports along its seaboard are only rivalled by the capital, which dominates the midlands. Rich agricultural lands and teeming factories are the principal sources of Sweden's agricultural and industrial wealth."

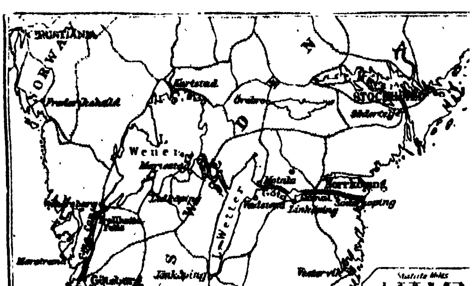
Contrasted with Norway. Here, evidently, is a land very different from that on the opposite slope of the mountains, in which a richer and more varied life is possible. Unlike the Norwegian, the Swede may hope to win a living from the land, with its triple gifts of corn lands, forest, and minerals. The highlands of Norway intercept the mild, rainy winds from the Atlantic, just as the western highlands do in Britain. There is the same contrast between the wet, mild, west Norway and the more extreme and drier east Sweden. In winter the Swedish ports are closed by ice, and a difficult line has been carried across the mountains to reach Narvik, the ice-free port for the northern iron mines in winter.

As in Norway, the summers are short, and almost continuously light, while the winters are long and dark. They are, however, more severe than in Norway. The duration of winter varies considerably. In Norrland ice and snow last about 200 days, against 150 in Central Sweden and 115 in the south. In the south the ice on river and lake breaks up in April, but further north not till May or June, according to latitude and elevation.

Resources of Sweden. These are threefold. In the flat south, wheat, barley, rye, and oats are grown, and much beetroot for the numerous sugar factories. In the undulating midlands innumerable farms are found in the forest clearings, the cattle being driven in summer up to the higher, richer pastures.

In the north neither the mountainous country nor the climate suits agriculture, though a little is carried on as far north as the Arctic Circle. This is the forest district, which supplies Sweden with her leading export—timber in various forms. Much is sawn in the forest, in mills turned by the innumerable streams. It may then be converted—by water-power, of course—into door or window frames, while the shorter lengths are made into matches, or wood-pulp, out of which much paper is now manufactured. In all these forms the forest helps to enrich Sweden. Mining is also extremely important; Swedish iron in particular, which is most abundant round Gellivara in Lapland and Dannemora in the centre, is of excellent quality and in great demand. Copper is mined at Falun, and there are other useful metals. Coal is scarce.

How the People Live. Outside the towns the Swede is a farmer, a forest worker, or a miner. In the towns he is a clever, industrious artisan, whose industries are rapidly growing. In the remoter districts, where communication between farm and town is difficult, the farmer must be farrier, blacksmith, wheelwright, etc., while his womenfolk spin and weave, and are the tailors of the family. In the mountain dales the picturesque old dresses are still worn, and life is lived very simply and frugally. The towns are attracting people from the country districts, and there are signs that Sweden is slowly changing to an industrial country. For such a career she has many advantages. A notable one is the excellent water communication. The great lakes are like inland seas. Wener Lake covers over 2,000 square miles. Lake Wetter is nearly 750 square miles, and



THE GOTA CANAL

Lake Mälar 500 square miles. Many canals have been cut to unite these and smaller lakes. The most important is the Göta Canal, from Göteborg (Gothenburg), the chief port, to Stockholm, the capital, by way of Lakes Wener and Mälar. As in Norway, most of the towns are on the coast. Göteborg, Helsingborg, Landskrona, Malmö, Karlskrona (the naval station), Norrköping, and Stockholm (the capital) may be looked out on the map. Of inland towns the most important are the universities of Lund and Upsala. Stockholm, built on islands connected by many bridges, is often called the Venice of the North. With its lakes and pinewoods, its hills crowned by palaces and churches, and its many fine buildings, it is one of the most picturesque capitals in Europe.

DENMARK

Denmark consists of the peninsula of Jutland on the mainland, the large islands of Fyen (Fünen) and Sealand, and many smaller ones. Look out these and the channels between on a map. Including the Faroe Islands and Iceland, its area is about 15,000 square miles. Neither mainland nor islands have hills over 600 ft. high. The scenery owes its charm to the contrast between the cultivated shores and the winding straits. Jutland has low, sandy shores with many lagoons on the west coast, and a somewhat higher shore, with better harbours, on the east. After the primeval beech-forests disappeared, it passed into boggy, treeless moorland, almost impossible to cultivate. Within the last century much has been converted into excellent meadow or agricultural land by draining, and by planting trees on the western or windward side. Roads and railways now penetrate prosperous districts which, in the lifetime of their inhabitants, were inaccessible and houseless moorlands. Four-fifths of the country is now productive.

Denmark is in the latitude of Southern Scotland, and has a similar climate, with rather colder winters and warmer summers. There is sufficient rain to keep the meadows green. The Baltic is frozen in winter, and the Sound and other channels occasionally blocked with ice.

Danish Industry. The Dane is a model farmer and dairyman. By promoting education and using the best scientific methods, he has transformed a poor country into a prosperous one. Danish dairy produce, butter, bacon, and eggs, are famous for their excellent quality. Many dairy farmers work on the co-operative principle, which gives uniformity of quality at minimum cost. One large co-operative dairy handles the milk of over 6,000 cows daily. The chief agricultural crops are barley, rye, and sugar beet, with which are connected the industries of distilling and sugar-making. Denmark is a land of seas and islands, and most towns are naturally on the coast. To communicate between island and island, the trains are run on to ferry steamers. Look out on the map Esbjerg on the west coast of Jutland, Aarhuus and Fredericia on the east, Nyborg on Fyen, Gjedser in the south of Falster, and Elsinore, or Helsingor, and Copenhagen on the Sound. Copenhagen (Kjöbenhavn, meaning Merchants' Haven), the capital, is admirably situated for trade, at the entrance to the Baltic. Seen from the sea, its harbours crowded with shipping, and its spires outlined against the sky, it is extremely picturesque.

The Faroes, or Sheep Islands. Few of these are inhabited. Fishing and the keeping of sheep and ponies are the chief occupations.

Iceland. Iceland is a land of mountains, snow fields, volcanoes, geysers, long, hard winters, and short, light summers. Sheep and ponies are fed, and the men go to the Arctic fisheries. The fine scenery, including the active volcano of Hekla, attracts tourists in summer. The capital is Reykjavik, in the south-west.

A. J. AND F. D. HERBERTSON

The Master Sculptors of Florence—Ghiberti, Donatello, Luca della Robbia, and Michelangelo.

ART IN THE RENAISSANCE PERIOD

THE history of the early Renaissance is inseparably connected with the history of Florentine art. It is, indeed, difficult to follow the evolution of the revival in the three sister arts separately, because the giant minds of that period did not restrict their colossal activity to a single sphere, and mastered the terms of many arts. We have already seen how Giotto achieved greatness in painting, sculpture, and architecture.

Others there were in the fifteenth and sixteenth centuries who were goldsmiths and sculptors and painters; there was no art that Michelangelo did not master, and Leonardo da Vinci combined the functions of military engineer, musician, poet, writer of scientific treatises, and stage manager of glorious spectacles with those of painter, sculptor, and architect. There was a constant interchange of ideas, and each art left its mark on the sister arts; each step forward in the one was reflected by the others.

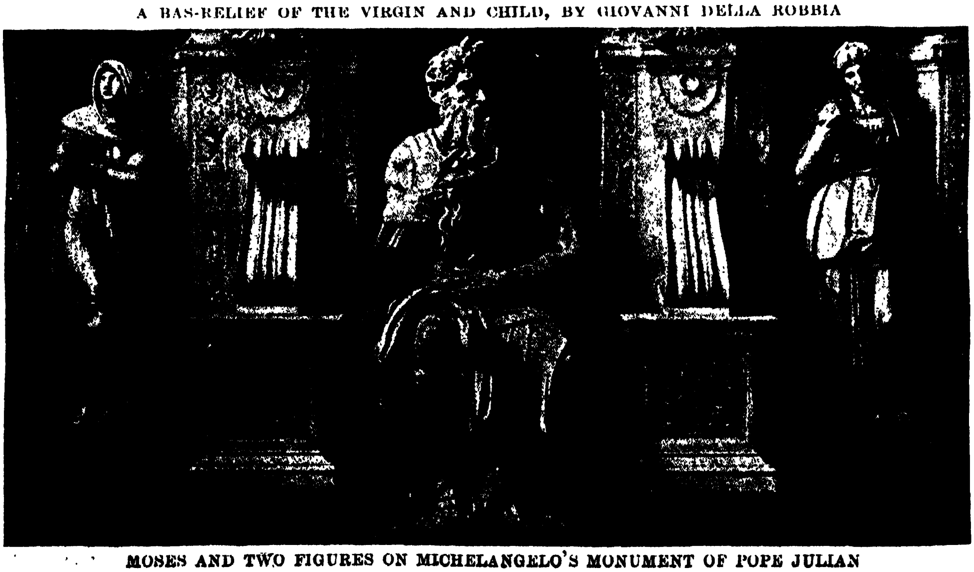
In architecture, the ideal form of the private dwelling was the greatest achievement of the Renaissance, and of Filippo Brunelleschi (1377 to 1466), its creator. The Gothic house was a kind of miniature fortress, with a narrow, high street-front, as few apertures as possible, and narrow, irregular passages, rooms, and winding stairs. With the growing wealth and luxury of Florence, and increased security of life, a new type of building had to be evolved, a palace that should express the new conditions, the wealth and power and taste of the merchant princes who ruled the city. Spaciousness, comfort, air and light were the primary considerations which led to the adoption of a wide street-front, a spacious ground plan with only a few storeys and suites of large, well-lighted rooms. The beauty of the façade is based on noble proportions, on the relation of the massive "rustica" masonry—composed of rough-hewn blocks finished off only at the joints—to the window openings, which are generally divided by columns or mullions, and the classic cornice or attic.

The most striking feature of the Florentine palace is the handsome inner court surrounded by slender colonnades, which are sometimes arranged in two tiers. The charm of the façade lies in the play of light and shade of the strong southern sun on the roughly hewn masonry, the arches and pilasters of the windows, and the boldly jutting cornice. Brunelleschi's Pitti Palace, Michelozzo's Riccardi Palace, and the wonderfully impressive Palazzo Strozzi, the plan of which is, with little show of reason, attributed to the sculptor Benedetto da Majano, are the noblest instances of the Renaissance palace, not only in Florence, but in the whole world. In Venice, the Palazzo Vendramin, graceful in form and resplendent in coloured marble casing, shows the adaptation of Venetian decorative devices to the style born in Florence; while, if we turn from secular to ecclesiastic architecture, in the façade of the Certosa di Pavia, begun in 1473 by Ambrogio Borgognone, with its wealth of marble incrustation, reliefs, niches, statues and medallions, the dignity of the style has given way to playful exuberance of ornamentation.

The great Cathedral of Florence, which had undergone many modifications in the two centuries of its building, received its imposing cupola by Brunelleschi, who thus solved a problem which had baulked the efforts of all his predecessors; but in spite of this dome it remains in its essential features a Gothic building. The churches of S. Lorenzo and S. Spirito, and the graceful Pazzi Chapel, are the three most important Renaissance churches built by this master. Alberti, the designer of the façade of S. Maria Novella, in Florence, and the inventor of the volutes masking on the exterior the junction of the nave and the lower aisles, went further than Brunelleschi in his adherence to the classic orders; he lacked the other master's inventive genius and sense of elegant proportions, and endeavoured to make all architectural forms fit in with his favourite theories.

GRACE AND STRENGTH IN THE RENAISSANCE

A BAS-RELIEF OF THE VIRGIN AND CHILD, BY GIOVANNI DELLA ROBBIA



MOSES AND TWO FIGURES ON MICHELANGELO'S MONUMENT OF POPE JULIAN

THREE MASTER SCULPTORS OF A GOLDEN AGE

THE VIRGIN AND CHILD, WITH TWO ANGELS, BY LUCA DELLA ROBBIA

DAVID, BY MICHELANGELO

ST. GEORGE, BY DONATELLO

In the sixteenth century the powerful and liberal patronage of the popes attracted the leading artists of the whole of Italy, and made Rome the centre of artistic activity. Here, on classic soil, architects were enabled to study the ruins of antiquity and to formulate their knowledge into a scientific system. True enough, the classic forms continued to be a mere outer garment which clothed the buildings that were adapted to modern requirements, but they were applied with better understanding of their functions, with increased sureness and purity. In the palaces the storeys were clearly divided by cornices, the windows framed by pilasters and surmounted by triangular or curved pediments of purely classic proportion. As regards the use of the "orders," the superimposed storeys led the eye from the heavier Doric, through the Ionic, to the graceful Corinthian. In church architecture the mighty dome, in conjunction with a barrel-vaulted nave, became the firmly established type of the later Renaissance.

Masters of the Renaissance. Bramante, who has left much of his early work in and around Milan, played in Rome the same part that Brunelleschi had played in Florence. He is the initiator of the second period, the first of the many builders who helped in the erection of St. Peter's, and the architect of the beautiful Cancelleria and Giraud Palaces. The great Raphael's chief building is the Palazzo Pandolfini, in Florence, where the alternating triangular and semicircular pediments over the windows are introduced for the first time. Antonio da Sangallo, the builder of the Farnese Palace in Rome; Baldassare Peruzzi, the scene of whose captivity was Siena; Giulio Romano, who worked in Mantua; Sansovino, the designer of the library of S. Marco and of the Zecca, or Mint, in Venice, are among the leading masters of the late Renaissance which culminated in the work of Michelangelo. In his striving for a grand general effect, without much concern with detail, he introduced the germ of the lawlessness which set in after his death and led to the exaggerated forms of the Baroque style. The gigantic cupola of St. Peter's in Rome, and the Medici Chapel in Florence, are his most famous architectural works.

Sculpture. In sculpture, as in architecture, Florence was the centre of the early Renaissance, but chronologically a Sienese master, Jacopo della Quercia, stands between the Gothic Orcagna and the first great sculptor of the new epoch, Ghiberti. Though in many ways still addicted to Gothic mannerisms, Jacopo is, in his boldness of vision and vigorous treatment of the human form, a true child of the Renaissance, and stands nearer to Michelangelo than any of the intervening Florentines. Ghiberti's greatest work is the gates of the Baptistery in Florence, of which Michelangelo said that they were worthy to be the gates of Paradise. In comparing them with Andrea Pisano's, one is immediately struck by the inimitable sense of beauty that pervades the later artist's work; the exquisite finish which betrays the goldsmith's training; the wonderful grouping of the figures in receding planes, and the corresponding variations in the relief treatment, from the foreground figures, which stand forth in their full roundness, to those in the far background, which are indicated by scarcely more than a few lines. In fact, Ghiberti was the first sculptor who made use of linear perspective in relief work, and we may say that his work is almost pictorial in character.

A BAS-RELIEF FROM THE SINGING GALLERY, FLORENCE, BY LUCA DELLA ROBBIA

Donatello is acknowledged to be the greatest, as he was the most productive, sculptor of the Renaissance. He lacked, perhaps, the pure sense of beauty of Ghiberti, but there is in his work something greater than formal beauty—the beauty of character, which renders the very harshness fascinating. Everything he wrought, in marble or in bronze, is full of expression and life, character and movement. Happily, too, his manifest leaning towards extreme realism was tempered by his knowledge and love of the antique. He worked from the living model, but had before his mind's eye the masterpieces of classic art. This is especially apparent in his bronze "David" at the Bargello, in Florence, the first nude bronze of modern times. There is nothing less than classic beauty in the graceful, well-balanced attitude and the well-shaped legs, whilst the thin, angular arms are copied from the living model. And yet the figure is quite homogeneous; it has the thrill of life, and in its very deviations from the classic ideal conveys the idea of the immature shepherd youth and giant-killer. And Donatello approached every successive task in the same objective spirit, dealt with each on its own merits, infused pulsing, throbbing life into cold stone or bronze. His "Gattamelata," in Padua, is the first equestrian statue since classic times, and has never been surpassed in impressiveness and dignity, with the single exception of Verrocchio's "Colleoni" in Venice.

The third great master sculptor of the early Renaissance was Luca della Robbia, the founder of a whole dynasty of workers in glazed terracotta, and at the same time one of the leading

THREE WONDERFUL PIECES OF SCULPTURE

BENVENUTO CELLINI'S STATUE OF PERSEUS

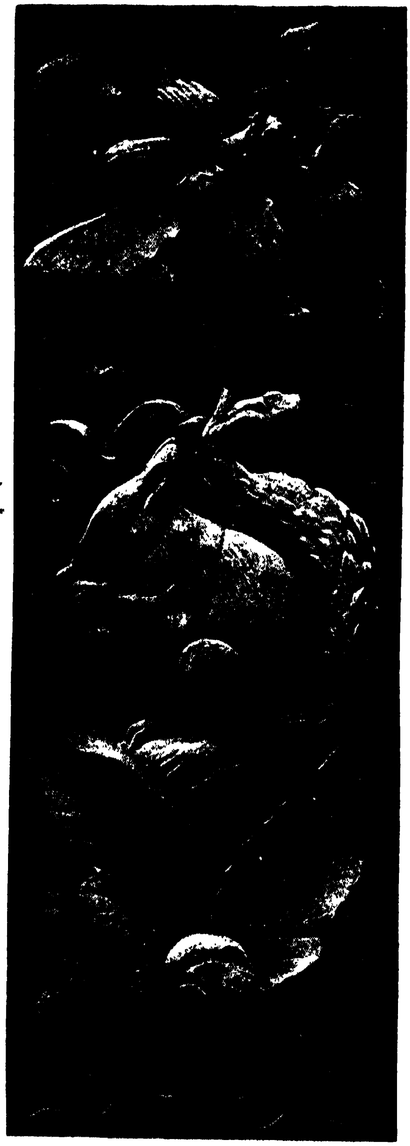
BOLOGNA'S STATUE OF MERCURY

DONATELLO'S STATUE OF GENERAL GATTAMELATA

sculptors in marble. Of all the early Renaissance sculptors, Luca was the one that came nearest to the Greek spirit of calm serenity, though in subject matter he was further from the antique than any of his contemporaries. Motherly love and tenderness and happiness were his favourite themes, and have perhaps never found more beautiful expression in plastic art. Of his marble works the most famous is the singing gallery, in Florence.

Donatello was followed by a whole school of great marble-workers who devoted themselves chiefly to tomb monuments and portraiture. The tomb of the period was generally conceived in the form of a recumbent figure of the dead on a sarcophagus in a niche, the architectural setting being in perfect harmony with the purely sculptured part, and richly decorated. Desiderio da Settignano, Mino da Fiesole, Rossellino, Benedetto da Majano, and Pollajuolo must be mentioned among the leading masters of the fifteenth century. Verrocchio, who excelled in bronze work, and is the creator of the world's greatest equestrian statue—the Colleoni monument in Venice—has left comparatively few works, but exercised an enormous influence as a teacher. Leonardo da Vinci was one of his pupils, and the first suggestion of the enigmatic type of face, which is always associated with Leonardo's work, can be found in Verrocchio's bronze "David" at the Bargello, in Florence.

Michelangelo. Sixteenth century sculpture is overtowered by the mighty genius of Michelangelo, whose work is the embodiment of the highest ideals of the late Renaissance. To the close of his earlier period belongs his colossal "David," that wonderful figure of a youthful, well-proportioned giant which the master chiselled out of a spoilt block of marble.



A DETAIL FROM THE FRIEZE ON THE FAMOUS DOOR OF THE BAPTISTERY, FLORENCE, BY LORENZO GHIBERTI

In his later work Michelangelo to a certain extent broke away from the Greek ideal, as he had broken away from everything that had gone before him, to find an adequate expression for his passionate spirit. As a poet for the sake of emphasis is allowed to change the natural proportion of speech, so Michelangelo in sculpture departed from strict truth to nature, exaggerating certain actions or muscles or limbs, for the sake of accent and increased impressiveness. At the same time he knew, like no other master, how to vary the texture of the surface to secure the desired effects of light and shade. The tombs of Lorenzo and Giuliano de Medici, with the attendant figures of "Night and Day," "Dawn and Twilight," mark the height of his achievement.

Between the early Renaissance and Michelangelo stands Andrea Sansovino, the creator of the Cardinal Sforza tomb at S. Maria del Popolo, in Rome, a monument which shows Andrea's complete mastery of classic forms, though the sarcophagus with the recumbent figure is overwhelmed by the architectural setting and subsidiary figures. Of the other masters of the period only Giovanni da Bologna and Benvenuto Cellini did not succumb to the influence of Michelangelo, which proved baneful to all others who succeeded him and contented themselves with turning his style into mannerism by absurd exaggeration of distorted proportions. Baccio Bandinelli is the typical sculptor of this period of decline.

Giovanni da Bologna's bronze "Mercury," with its fine expression of swift upward movement and its brilliant adaptation of the modelling to the material, is the work by which this master will be best remembered, whilst Benvenuto Cellini, the sculptor-goldsmith, whose chief fault was that he treated monumental sculpture in the spirit of the goldsmith, and his goldsmith work in that of the sculptor, has left the world the famous "Perseus" in the Loggia de' Lanzi, in Florence.

A special branch of sculpture, which reached its highest development in the early days of the Renaissance, is the art of the medallist. Vittore Pisano, who flourished in Northern Italy in the early fifteenth century, was the first great medallist, and remained unsurpassed.

P. G. KONODY

A RENAISSANCE INTERIOR AND EXTERIOR

THE WEST FRONT OF ST. PETER'S, ROME—THE DOME BY MICHELANGELO

THE INTERIOR OF THE CHURCH OF S. SPIRITO, FLORENCE, BY FILIPPO BRUNELLESCHI

The Principal Bones of the Head, Trunk, and Limbs. The Spinal Column. How Bones are Jointed.

THE FRAMEWORK OF THE BODY

In considering the locomotive system we have to examine first its structure, and then its function. It is composed of bones, joints, and muscles; and while describing these with sufficient fulness to be clearly understood, all needless details will be omitted, and technicalities avoided.

The Bones. We begin with the bones, concerning which a few words have already been said in an earlier chapter in speaking of the body as a whole, and we shall not, therefore, here repeat details of the information.

Bones are the framework of the body. They support the soft parts and protect the various organs. Here [**53**] is shown the skeleton of an adult man, and reference should also be made to the picture on page 161 of this work.

The organs of most importance are well guarded from injury, the *brain* by the *skull*, the *spinal cord* by the *spine*, the *eyes* by the *orbit*, the *heart* and *lungs* by the *chest-wall*.

We have pointed out that there are about 200 bones in the adult body, which may be divided into six parts—head, trunk, and four limbs—giving a little over 30 bones to each part. We will look at them in detail.

The head and neck contain 30 bones. The head, or skull, contains 22, of which *eight* make up the cranium, or skull proper—the part that contains the brain—and *fourteen* the face. Only one of these 22 can move, and that is the lower jawbone, which is seldom still.

Bones of the Cranium. The eight bones that make up the cranium are only separate in the young child's head, where their edges lock closely together with teeth, like a saw.

By degrees, the bones grow together, so that in the adult they cannot be separated any more; only the lines where they are joined can still be seen; they are called sutures, because they look just as if the bones were sewn together. The reason they are separate at first is to allow the brain to grow to its full size, and then they unite together to protect it more thoroughly.

The eight bones are as follow [**59**, **60**]:

One frontal bone, which forms the forehead.

Two parietal bones, which form the vault.

Two temporal bones, which form the temples, at the sides.

One occipital, which forms the back of the skull. One sphenoid and one ethmoid, which form the base of the skull and the back of the face.

The frontal bone, so called because it is in front, is the shape of a large cockle or escallop shell, and forms the front of the head and the top of the orbits. It is the only bone in the head that contains air, in the two cells that form the elevations over the eyebrows. In the elephant these two air-cells are enormous, and give him such big bumps on the forehead.

The parietal bones (Latin *paries*, a wall) form a great part of the dome of the head. The temporal bones are so called because they form the temples. Temple comes from Latin *tempus*, time or age, and is so named because the hair first turns grey there in old age. The occipital bone is so named from Latin *occiput*, the back part of the head. This bone connects the rest of the cranium with the top of the backbone, or spine, and has a large hole in the bottom of it through which the spinal cord (or marrow) passes out of the brain.

The sphenoid, or wedge bone, forms the front of the floor of the cranium, and is like a flying bird in shape. The ethmoid, or sieve bone, is placed below the frontal bone at the back of the face. It is called a sieve because it is pierced with many small holes, to allow the fine nerves of smell to pass through.

The Face. In the face [**60**] are 14 bones, all in pairs (right and left), except two. They are:

Two superior maxillary, or upper jawbones.

Two palatal bones (in the mouth).

Two malar, or cheek bones.

Two nasal, or nose bones.

Two lachrymal, or tear bones.

Two turbinated, or nostril bones.

One vomer, or partition between the nostrils.

One inferior maxillary, or lower jawbone, the only one that moves.

The superior maxillary bones are so called from Latin *maxilla*, a jaw. In them the upper teeth are set. They form the front of the roof of the mouth or *hard palate*, and the sides of the nose. The palate forms the back of the roof of the mouth.

The malar bones (Latin *mala*, cheek) are the cheekbones, and form the hard ridge under the cheek, and also the lower parts of the *orbits*, in which the eyes are set. The nasal bones (Latin *nasus*, nose) form the bridge of the nose. The lachrymal bones (from Latin *lachryma*, a tear) conduct the tears from the eyes into the upper part of the nose. The turbinated bones (Latin *turbo*, a scroll) are rolled round in the shape of a scroll of paper, and form the inside of the nose and the organ of smell. They also serve to filter and warm the air. The vomer (Latin *vomer*, a ploughshare) helps to form the bridge of the nose. In the inferior maxillary bones are fixed all the lower teeth.

Thickness of the Skull. The cranium varies greatly in thickness in different parts. Where it is most exposed to injury, as on the top and forehead, it is thickest, the bone often being ¼ in., whereas, in the temple, just in front of the ear, it is not thicker than paper in one part. The special structure of these flat bones of the cranium serves to protect

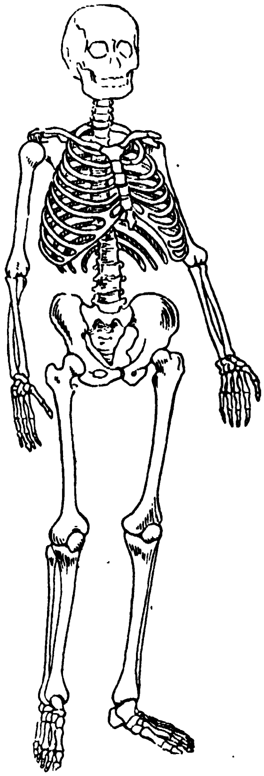
the brain from shock. They are made of two flat plates, with a network of spongy bone between. This arrangement prevents the shock of blows on the head (if not too violent) from reaching the brain. This we can prove by putting two flat pieces of wood (one on the other) in the hand; if we strike the upper piece, we can feel the shock in our hand. But if we now put a piece of soft flannel or felt between the two—like the spongy tissue between the bony plates—and strike the upper wood, we feel nothing, because the vibration is stopped.

The vaulted shape of the cranium gives it also great strength. No parts of the body are protected so carefully from injury as the brain and spinal cord.

Bones of the Neck and Trunk. In the neck there are eight bones, of which seven form the upper part of the spine or backbone, and the eighth is a bone in the throat, which can be felt beneath the lower jaw. It is the hyoid bone, or bone like a "U," because it is just the shape of one, with the round part forward. It supports the upper part of the windpipe.

In the trunk there are 30 bones, if the ribs are counted in pairs—17 vertebræ in the back, 12 pairs of ribs at the sides, and one breastbone, or sternum, in front.

The trunk is divided into the *chest* and *abdomen*. The chest or thorax is a bony cage formed by the spine behind, the *ribs* at the side, and the breast-bone in front, and contains the lungs and heart. The abdomen has only the spine behind, and no bones in front.



53. THE HUMAN SKELETON

The Vertebræ. The backbone, or spine, is made up altogether of 33 vertebræ or turning bones, which are so named because most of them can turn a little on their own axis.

The first seven form the neck or cervical vertebræ; the next twelve form the back or dorsal [56a]; the following five form the loins or lumbar [56b]; and the next five are united into one bone called the sacrum, or sacred bone. The last four are also joined into one bone called the coccyx, or cuckoo bone, and these two form the back of the hips.

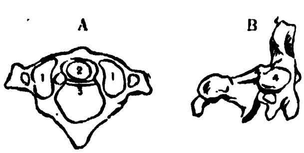
These vertebræ are placed one on the top of another, like so many bricks, and each one is separated from the next by a stout pad of cartilage or gristle, which, like the spongy bone between the two hard plates of the skull bones, prevents any shock from reaching the brain.

Although the spine contains 33 vertebræ in man, we see that five and four are joined together; and thus there are only 26 separate bones. In the child, on the other hand, each vertebra is made up of several separate parts, so that there are nearly 200 pieces of bone to form the 33 vertebræ.

Shape of a Vertebra. A vertebra is something like the figure eight, with one of the circles made solid in front, and the other one left open and forming a ring behind; so that when all the bones are placed on one another, the solid discs in front form a bony column, and the rings behind form a long tube. The column supports the body, and the tube contains the *spinal cord*, or *marrow*.

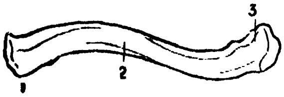
The ring behind has three bony projections, one on each side (transverse process), and one behind (spinal process), and it is the tips of those processes, one below another, that are felt as ridges of the spine behind. They are for the attachment of the strong muscles which support the long column called the spine.

Use of the Padding. If we put 26 reels of cotton on the top of each other, with a soft pad between each for the cartilage, we can see



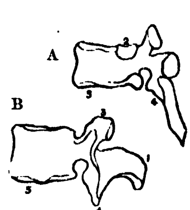
54. ATLAS AXIS

1 and **4.** Articulation. **2.** Peg, or Odontoid process. **3.** Ligament.



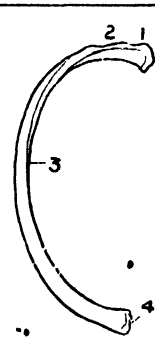
55. CLAVICLE (right side)

1. Inner or sternal end joins handle of breast-bone. **2.** Shaft. **3.** Outer or scapular end.



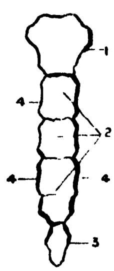
56. (a) DORSAL VERTEBRA
(b) LUMBAR VERTEBRA

1. Spinal process.
2. Articulation.
3. Lateral process.
4. Inferior articulation.
5. Body.



57. TRUE RIB

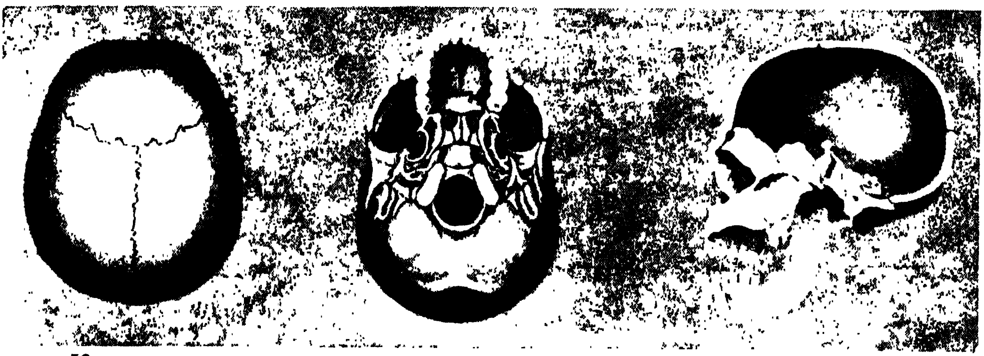
1. Head. **2.** Neck. **3.** Body. **4.** Junction with sternum.



58. STERNUM

1. Handle or manubrium.
2. Body.
3. Ensiform process.
4. Attachment of rib cartilage.

how easily a little pressure from above would force the column to one side or the other. The pads prevent friction and jarring. The spine is only kept straight by exercising its muscles, and girls especially should have as much drill and exercise as possible, to strengthen this spinal column. The spine is naturally bent backward in a curve which makes the beautiful spring on which the head is poised.



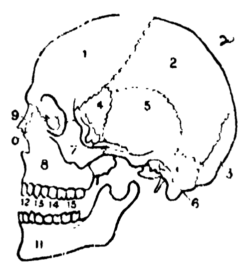
59. THE HUMAN SKULL AS VIEWED FROM THE TOP, FROM BELOW, AND IN SECTION

The Atlas and the Axis. The top vertebra of the seven in the neck is called the *Atlas* [54A], as it supports the head, just as the fabled Greek god Atlas carried the heavens on his shoulders. It consists of a strong, bony ring, divided in two by a fibrous band. On the upper surface are two smooth sockets, on which the lower part of the occipital bone of the skull rests, and on which the head moves backward and forward, as when we nod and say "Yes." Through the back part of the ring the spinal cord passes into the brain by the great opening in the occipital bone.

The second vertebra is called the *Axis* [54B], because in front of it is a strong, bony peg about an inch long, passing up through the front of the ring of the atlas, and on which it and the head can turn from side to side, as when we shake the head and say "No."

Meaning of a Broken Neck. If this peg breaks through the fibrous band across the atlas, as in hanging, it presses on the spinal cord behind, and causes instant death, and the person is said to have his neck broken.

To see how this is done, make a ring with the first finger and thumb of the left hand, and then tie a thread to stretch across it from the middle of the finger to the middle of the thumb; then put the forefinger of the right hand up though the front division to represent the peg of the axis, and put the thumb through the other division to represent the spinal cord. If we then break the thread by pushing backward with the right forefinger, and press on the thumb, we see exactly how a man's neck is broken.



60. THE HUMAN SKULL

1. Frontal bone **2.** Parietal bone **3.** Occipital bone **4.** Sphenoid bone **5** Temporal bone **6.** Styloid process **7.** Malar bone **8.** Superior Maxilla **9.** Nasal bone **10.** Lachrymal bone **11.** Inferior Maxilla **12.** Incisors **13.** Canine teeth **14.** Bicuspids **15.** Molars

The other vertebræ are all pretty much alike, only, the lower they go down, the larger and stronger they become in every way [56], until the last of the twenty-four rests upon the *sacrum*, which forms the back of the hips.

The Ribs. The Ribs [57] are long bones curved in a semicircle forming the cage, called the thorax, which holds the lungs and the heart. There are 12 pairs of them attached to the 12 upper vertebræ of the back, so that there are 12 vertebræ without ribs (*seven* in the neck above and *five* below), and 12 with them. The seven upper pairs of ribs are also hinged in front on to the breast-bone, and are called true ribs; the other five pairs are not so hinged, and are called false ribs. These ribs are, however, united by cartilage in front to the lowest true rib, excepting the last two pairs, which are not fastened in front at all, and are sometimes called floating, or *free*, ribs. Frogs have no ribs, but snakes have hundreds, on which they move. They use them instead of limbs, and the flying lizard flies with its ribs.

The Breast-bone and Collar-bone. The Breast-bone is called the *Sternum* [58], or sword, because it is just the shape of a short Roman sword or dagger in its sheath, with the handle above and the point downward, which we can feel in the middle of the chest. To the handle above, the arms are attached on each side by means of the collar-bones.

The Clavicle [55], or collar-bone, is so called from Latin *clavis*, a key, and is fastened to the sternum at the inner end, and at the outer end to the shoulder-blade, with which it completes the socket for holding the arm. It is the shape of the letter "S," which is like an ancient key, and keeps the shoulders in their place. In animals, all of which have narrow, deep chests, these bones are very short indeed. The clavicle is easily broken by a fall upon the hands or arms. The two collar-bones in a fowl together form the "merry-thought."

The Shoulder-blade. The Scapula, or shoulder-blade (Latin *scapula*, a little boat), is a flat, triangular bone resting over the muscles of the back, on which it freely moves. It is united

to the clavicle above, and forms the socket for the arm by means of a shallow cup at the outer angle, the point of the triangle being downward.

The Arm. The Arm [62] contains 30 bones, and is divided into three parts: the upper-arm. with one bone; the forearm, with two bones; and the hand and wrist, with 27.

The Humerus (Latin *humerus*, shoulder) is the name of the arm-bone. It has a rounded head above, fitting into the socket in the shoulder-blade, which is so very shallow that the shoulder is easily put out of joint—ten times as frequently as any other bone in the body. It is so shallow in order to allow free movement of the arm in every direction. The lower end of the humerus is broad, and shaped like a door-hinge.

The Ulna is so called because it forms the elbow, and is the inner bone of the forearm. It has a broad socket above, exactly fitting into the end of the humerus, and forms a strong hinge-joint; it is pointed. below. The end of the ulna, which makes the tip of the elbow, locks into the humerus when it is extended, and by this means prevents the arm from folding backward.

Bones of the Forearm. The Radius (Latin *radius*, a spoke) is the outer bone of the forearm. It is narrow above and broad below, where it joins the wrist and carries the hand. This bone moves above and below in two strong rings that join it to the ulna and enable it to turn round it. If we place one of our forearms and the back of the hand on a table, the radius is the outer bone and the ulna the inner. Now, without raising the arm or moving the elbow, we can turn the hand right over, palm downward, and we can see and feel the radius turning over the ulna, which has never moved at all. Remember *the radius turns, and forms the wrist-joint; the ulna is fixed, and forms the elbow-joint.* The elbow-joint is twisted a little inward, so that the forearm does not fold straight on to the arm, but centrally, toward the mouth, where it is much more useful, as we very seldom put our hand on the shoulder of the same side, but often use it to carry food to the mouth.

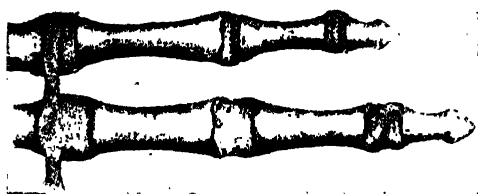
Bones of the Hand. The Hand [63] may be divided into three parts: the *wrist*, which has eight bones; the *hand*, which has five bones; and the *fingers*, which have 14 bones. The bones of the wrist are short and square, and are all so united by fibrous tissue that each can bend slightly, and thus they make flexible but very strong joints. They are called carpal bones (Latin *carpus*, a wrist). The hand is formed of five bones, which can be felt along the back of a thin hand; they are called metacarpal (Greek *meta*, beyond; *carpus*, wrist).

The fourteen bones of the fingers are called phalanges (Greek *phalanx*, a rank), because they stand in rows, like so many soldiers; three form each finger, and two form the thumb. The use of so many bones is not only to give every possible variety of movement, but to give great resistance to any blow or shock, as in falling on the hands.

Bones of the Legs. The Hips are constructed of four bones which, joined together, make what is called the *pelvis*, or basin, because it is like a basin with the bottom out. The four bones are the *sacrum* and *coccyx*, forming the base of the spine behind, and the two *hip-bones* (called *ossa innominata*, or nameless bones), one at each side, which meet in front. This basin holds and supports the lower organs of the body, and is broader and stronger in man than in any animal, in order to maintain his upright position. The two very deep *cups* or *sockets* on the outer side of the hip-bones are for the heads of the thigh-bones.

The Legs [62] are divided into three parts, like the arms, and composed of exactly the same number of bones, only that, as the bone that corresponds to the tip of the elbow, and forms the front of the knee, is separate, we count one for the thigh, three for the leg instead of two, and 26 for the foot instead of 27, because there are only seven bones in the ankle and instep.

The Femur, or thigh-bone, is the longest and strongest bone in the body, and longer in



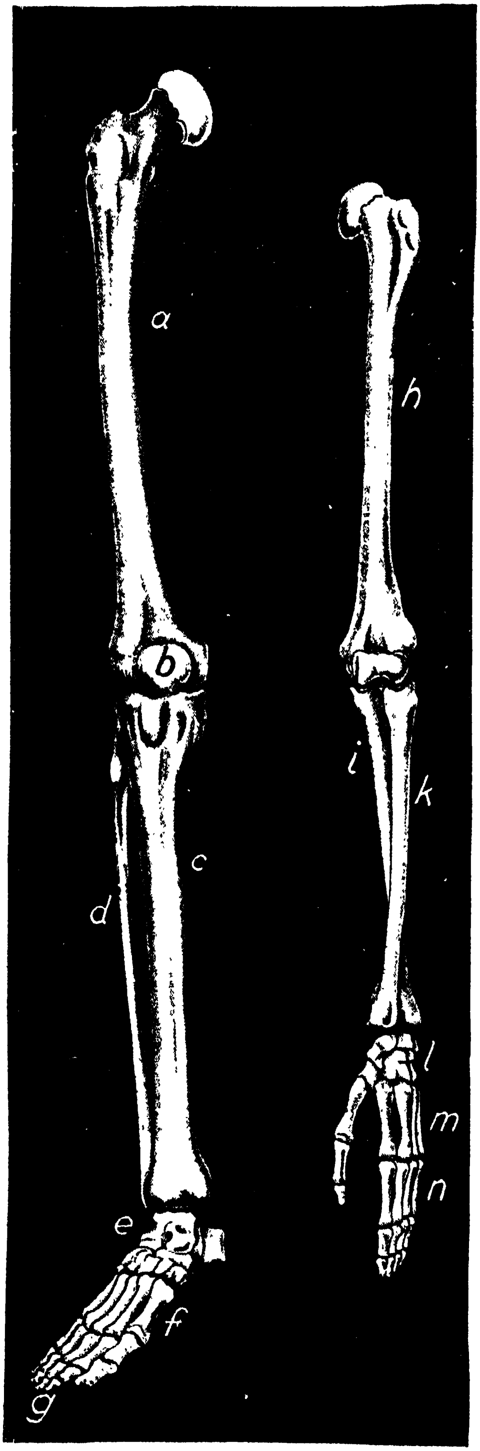
61. THE MIDDLE AND THIRD FINGERS OF THE HAND, SHOWING THE CONNECTING LIGAMENT

proportion than that of any other animal. The head of this bone is very round, and fits firmly into the deep cup of the hip-bone, so that, while the leg cannot move so freely as the arm-bone, it is much less likely to be dislocated. The lower end of the bone is broad and flat to form the knee.

The Tibia, or flute-bone, is the large bone of the leg. Unlike the ulna in the arm, which only forms one joint, it not only forms the knee-joint above, but the ankle-joint below. We can trace it all along, just under the skin, where it is called the *shin.*

The Fibula (or buckle-bone) is so called because the knee-buckle used to be worn over it, on the outer side of the leg. It is a long, thin bone, fixed at the outer side of the tibia, and corresponds to the *radius* in the arm, but, unlike it, does not form the lower joint, but only protects the outer side of it. Neither can it turn round the other bone, for we do not require to turn our feet over, as we do our hands. The Patella, or knee-cap, protects the front of the knee-joint.

Bones of the Foot. The Foot has 26 bones, and may be divided into *ankle, foot,* and *toes.* The ankle (and instep) is formed of seven short, strong tarsal bones, much larger than the carpal bones of the hand; one of them forms the heel; the others make up the beautiful arch of the foot called the instep. The foot is formed, like the hand, of five long



62. THE BONES OF THE LEG AND THE ARM

a, femur, or thigh-bone; *b*, patella, or knee-cap; *c*, tibia, or flute-bone; *d*, fibula, or buckle-bone; *e*, tarsus, or ankle; *f*, metatarsus; *g*, phalanges, or toes; *h*, humerus; *j*, ulna; *k*, radius; *l*, carpus, or wrist; *m*, metacarpus; *n*, fingers.

bones, called metatarsal. The toes are called phalanges like the finger bones, and are also 14 in number.

We will now compare the arm with the leg, and we will see that, though there is a general correspondence, there are radical differences, so that in no sense is the arm a sort of fore-leg. The bones are all smaller and shorter in the arms, the joints are much weaker and more flexible. The shoulder and hip joints are both formed on the same principle, and yet one is almost the weakest joint in the body, and the other one of the strongest. The knee and elbow differ still more, the former being entirely made for supporting weight on its broad, flat surface, the latter for the easy movement of a door on its hinges. The ankle and wrist are entirely different joints; the wrist is made for limited but firm movements in all directions; the ankle for the foot to move, as the elbow does, up and down like a hinge. Then, as we have seen, the hand can be turned over backward or forward; the foot, of course, cannot. The heel in the foot, formed of one of the strongest bones of the ankle, has no counterpart in the hand.

How the Bones are Jointed. We now turn to consider joints, which really are the hinges on which the bones move. The ends of the bones composing a joint are smooth, enlarged, and rounded so as to fit, more or less closely, into one another. The bone itself, near the joint, is all hard, compact tissue, and is covered with a smooth layer of cartilage. Bones are united by a fibrous capsule attached round each, and lined with a fine membrane (called synovial membrane) which secretes a lubricating fluid (like the white of an egg) called synovia. The joints are often strengthened by various bands and ligaments.

All the different bones of the body are connected by joints, or articulations, of some sort. These joints, or hinges, are of three varieties: immovable, partly movable, and movable.

1. Immovable joints are formed by the joining of two bones together in such a way that they practically become one. The separate bones of the head and face are all thus united, except the lower jaw-bone, which is the only one that has a movable joint. The bones of the skull have edges like a saw, which lock into each other, leaving just a line where they were once divided. The teeth are also firmly fixed in the jaw, and cannot move till they fall out.

2. In partly movable joints, the bones do not absolutely unite, but are covered, where they join, with a little gristle, and are bound together by strong bands that fix them very firmly, but just allow the least possible movement on each other. It is in this way that the hip-bones are joined to form the pelvis, and the vertebræ to form the spine. The bones of the ankle and wrist are joined in the same manner.

3. In the case of movable-joints the ends of the bones are expanded and made to fit each other, frequently in the shape of a cup and ball. They are constructed in the way we have already described. These movable joints are of

four distinct varieties—ball-and-socket joint, hinge joint, gliding joint, and pivot joint.

The *ball-and-socket joint* resembles a ball fixed in a cup so as to move freely any way.

63. THE POSITION OF THE BONES IN THE HAND

This is seen at the shoulder and hip. In the *hinge joint* one surface is fitted into the other, so that the bone can only move backward and forward, like a door on its hinge. We find this at the elbow [64] and knuckles of the fingers. In the *gliding joint*, one bone slides on another freely, as at the ends of the collar-bone, in some of the wrist and ankle bones, and in the knee-joint. In the *pivot joint* a pivot works in a ring, like the hinge on some iron gates. It is found at the top of the radius, where the bone turns in a fibrous ring; and in the atlas and axis, where the one forms the ring and the other the pivot, enabling the head to turn from side to side.

All the joints of the head, as we have seen, are fixed joints, except the lower jaw. This is both a sliding and hinge joint, and sometimes, if we yawn or gape too much, it slides out of its socket, and our mouth is fixed wide open, the jaw being said to be *dislocated*, or *out of joint*.

We have shown that *nodding is a sliding action between the head and the atlas, and that shaking the head is a ring-and-pivot motion between the atlas and axis.*

All the ribs are hinged on to the vertebræ so as to move up and down in breathing like the handle of a bucket.

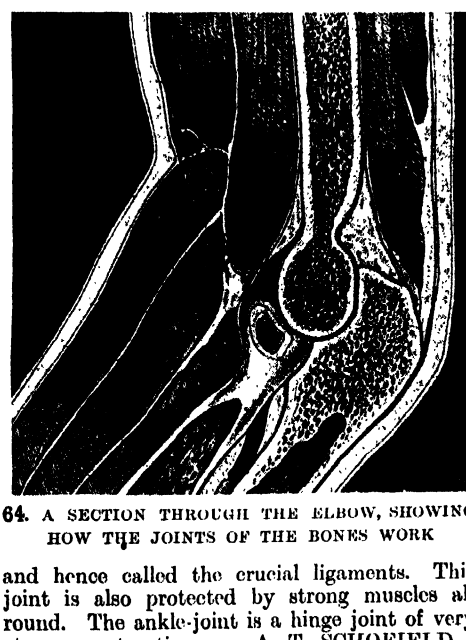
Movements of the Arm and Foot. The arm, being fixed at the shoulder in a loose ball-and-socket joint, is capable of circumduction, or movement round in *both directions*. The elbow, being only a hinge joint, can, of course, only move two ways—backward and forward. The joint at the knuckles of the hand [61] (not of the fingers) is a peculiar one, and is shaped like a saddle. We can spread our fingers and move them sideways, as well as move them backward and forward, just as in a saddle we can rock in our seat from side to side, as well as backward and forward. So that these joints are not ball-and-socket joints, and will not move all ways, like the shoulder; nor are they merely hinge joints, like the knuckles of the fingers, which only move backward and forward, but are a sort of double hinge, allowing a side movement as well.

The foot and toes are on the same pattern as the hand, but do not move nearly so freely. The joint of the big toe is often dislocated by ill-shaped boots, which press it too much outward toward the other toes.

We have seen that the *pleura* between the lungs and ribs forms a sort of joint, because one surface of the closed bag glides on the other, and in the same way the *pericardium* round the heart and the *peritonium* round the digestive organs also resemble joints; so that rheumatism, which always attacks the joints, often settles here, as well as in the limbs.

The hip is a very strong ball-and-socket joint, and the only things that prevent the thigh moving in all directions are the strong bands that are attached around it.

The knee, having only two flat surfaces, looks as if it could easily be put out of joint, but really it is a very strong joint, as the two bones not merely glide on each other, but are firmly united together by two very strong bands of fibre in the middle of the joint, passing from one bone to the other in the form of a cross,



64. A SECTION THROUGH THE ELBOW, SHOWING HOW THE JOINTS OF THE BONES WORK

and hence called the crucial ligaments. This joint is also protected by strong muscles all round. The ankle-joint is a hinge joint of very strong construction. A. T. SCHOFIELD

Preservation of Green Fodder in Silos. How to Build and Fill a Silo. Sour and Sweet Silage. Crops Suited for Silage.

THE ENSILAGE SYSTEM

ENSILAGE, a word which is derived from the French *ensiler*—to seal up—is the process of preserving green fodder either in a stack or a properly constructed silo. The "silo" is a receptacle or apartment so built that the air cannot pass through its walls or floor, while the word "silage" denotes the material which has been preserved. Whether silage is stacked in the open or preserved in a silo, it is necessary to weight it heavily to exclude the air, and thus to prevent excessive fermentation.

Value of the Silo. The ensilage system was initiated in this country at a time when frequent bad seasons were accompanied by the destruction of large quantities of partially made hay, but since that date it has been comparatively little practised, owing to better seasons, to the more extensive use of rapid haymaking machinery, and to the general preference of the farmer for hay. We do not, however, in England value the process as we should, inasmuch as it is adapted for the preservation of certain forage crops which are of extreme value in winter, and which cannot be systematically preserved in any other way. In the United States and Canada, maize, which can be equally well grown throughout a large part of England, is preserved in the silo on a large scale for winter use. With us, vetches, peas, lucerne, and trifolium incarnatum are well adapted to preservation in the silo, and if grown for the purpose, together with maize, they would materially add to the winter food supply. In some cases mixed grasses and clovers, cereals and pulse, have been preserved with great success, and the remark equally applies to the top of the Jerusalem artichoke, to sunflower stalks and heads, and maize chopped and mixed at the time of pitting.

Building and Filling a Silo. When the silo is properly filled and pressed, the fodder is practically kept in a sealed condition. Its walls must be smooth, and the bricks, where these are used, faced with cement, and finished with a steel float, while the corners should be rounded off so as to minimise the quantity of air retained. In filling, the process should be gradual, one layer being allowed to settle before another is brought in. The fodder should be well trodden, especially around the sides, with the object of compressing it as much as possible. It was at first supposed that grass and other green crops intended for silage could be cut and carted during any weather with equal success, but this is not the case. To fill the silo with fodder heavily wetted by rain is to court partial or entire failure.

The success of silage manufacture depends upon control of the temperature; but here it is necessary to explain that there are two classes of silage, the sweet and the sour, with their various gradations.

Sour and Sweet Silage. If a silo, having been gradually filled and trodden from day to day is finally pressed, whether by the aid of a mechanical appliance or by a dead weight, and pressure is applied too early, the result may be the production of sour silage. On the other hand, pressure being applied at a later period, the silage will probably be sweet, owing to the fact that heating or oxidation has intervened. In a word, if the temperature does not exceed 125° to 130° F., the silage will be more or less sour; whereas, if it reaches from 140° to 160° F., it will be more or less sweet. With the application of high pressure at an early period oxidation is checked, and the temperature fails to rise; whereas, if pressure is deferred, heating is encouraged, and the temperature rises to the degree already suggested. It must not, however, be allowed to go too far, or the result will be, as in the case of an overheated haystack, spoiled fodder, and consequent loss. Although there are many producers who make and even prefer sour silage, the production of which is almost unavoidable with the most succulent fodder crops, it is not to be regarded as a food for dairy cows, owing to its pungent odour, and to the fact that it is almost impossible to prevent it conveying a taint to milk.

Sweet Silage More Nutritious. Sweet silage, which is more agreeable both in odour and flavour, is regarded as the more nutritious. It owes its sweetness to the destruction of the organism to which acid fermentation is due. Grass silage contains from 71 to 72 per cent. of water, or slightly less than grass; while the soluble feeding materials, the albuminoids and carbohydrates, are slightly increased, the insoluble albuminoids and digestible fibre are decreased in quantity. Silage, and especially that which is sour, contains acetic and other acids, although the percentage varies with the temperature at which the fodder has been made. As compared with hay, which loses considerable weight in the process of drying, the loss of weight as between grass and silage is much less considerable. In round numbers, while grass loses 20 per cent. of its weight during its conversion into silage, it loses 70 to 75 per cent. during its conversion into hay.

The colour of silage should be bright, and the flowers of the plants well preserved. Where, however, it is made at a high temperature, the colour deepens materially, until, having passed 160° F. by several degrees, it becomes a deep brown, and thus resembles burnt hay.

Crops Most Suitable for Silage. A good crop should never be preserved in a silo if it can be converted into hay. Silage has no market value, whatever it may be worth on the farm; and although there is no ostensible reason why it should not be used for stock of various kinds as systematically as hay, there is greater risk in its production, owing to general want of knowledge on the part of both farmers and workmen, while the loss which may follow the opening of a stack or silo, and consequent exposure to the air, is much greater than that involved in the opening of a hayrick. We cannot refrain, however, from emphasising the value of the system to those who are able to grow such foods as maize and vetches. In the preservation of maize, which may be grown at the rate of from 20 to 35 tons per acre, a silo is essential; while the fodder must be cut by a special machine, practically a large chaff-cutter, and packed as tightly as possible in an airtight silo.

Best Form of the Silo. A silo may be built in the form of a pit on the side of a hill for convenience in unloading and removing; it may be circular—a common plan in the United States—or it may be formed by running a wall across one end of any suitable and substantial building. A roof is essential, together with means of elevating the weighting material. Where a silo, having been gradually filled for more perfect treading and settlement, is ready for pressure, the fodder may be covered either with chaff or dried earth, which, if preferred, may be spread upon boards made to fit as closely as convenient, the object being to provide an even surface, and thus to ensure even pressure on the forage.

In the absence, however, of a mechanical press, bricks, bags of earth, or stones, blocks of concrete, or any similarly suitable material, may be placed on the top at the rate of 120 lb. to 200 lb. per square foot, the weight being increased with the depth of the silo and the quantity of forage it contains. It is a mistake to suppose that the ensilage process does more than reserve the material submitted to it. There are many who believe that the feeding value of silage is greater than that of the crop from which it has been produced. On the contrary, the value is slightly diminished, owing to the loss which follows heating, or oxidation.

Grass and other crops intended for silage should be cut when in bloom, and allowed to lie in the field sufficiently long to part with a small proportion of their moisture. In all cases the worst material, that cut around the hedgerows and roadsides, should be packed around the sides in the silo and covered over the top, for in both places there is usually a proportion spoiled.

JAMES LONG

MAIZE—A CROP FOR WHICH THE PRACTICE OF ENSILAGE IS ESSENTIAL
From a photograph by courtesy of the Government of Ontario

Forms, Simple Compounds and Allies of Carbon: Silicon, Tin, and Lead. Nitrogen and its Related Elements: Phosphorus, Arsenic, Antimony, Bismuth.

CARBON AND ALLIED ELEMENTS

Diamond. The diamond is almost absolutely pure carbon. Its nature was proved by the celebrated French chemist Lavoisier, who succeeded in burning diamonds, and proving that the sole product of their combustion was carbonic acid (CO_2). We know now also that if the diamond be raised to a white heat in the absence of oxygen, it swells up, and is transformed into a black mass, which is practically a shapeless lump of charcoal. Diamonds which are not perfectly white owe their colour to the presence of oxides of various metals, such as iron. Diamond is the hardest substance known. It occurs in many crystalline forms, but they are all derived from the cube. The property which gives it its peculiar beauty is its very high power of refracting light—that is to say, bending rays of light, and, incidentally, breaking them up. [See Optics, in the course of PHYSICS.] Diamonds are most abundantly found at the Cape and in Brazil, but formerly they were only known in the Deccan in India. The hardness of the diamond gives it a practical use as an instrument for cutting glass and for drilling rocks. The value of diamonds is variously stated to increase as the square or as the cube of their weight.

Graphite. Graphite is the second allotropic form of carbon which we have to consider. It occurs in Cornwall and Cumberland, in the United States, and elsewhere. The carbon which separates out from cast iron when it is slowly cooled is graphite. It crystallises in the form of six-sided plates. Apparently in order to confuse the student, graphite is known by two names which attempt to persuade him that it consists of lead. These are *blacklead* and *plumbago*. Besides its use in making pencils and blacking grates, graphite is also employed for the making of moulds for iron casting, and is also mixed with fireclay for the making of crucibles.

Charcoal. Charcoal is an amorphous form of carbon, and is obtained from two distinct sources. *Animal charcoal* is obtained from bones by heating them in the absence of air, and is thus also known as bone-black or bone-charcoal. It, however, is an exceedingly impure form of carbon, a very large part of it consisting of phosphate of lime. It has a peculiar affinity for colouring matters, and is used in the process of refining sugar so as to remove colouring matter from it. It is also an ingredient of blacking, and is employed as a pigment. Lampblack is another impure form of carbon, which is obtained by the imperfect combustion of oil, and is also used as a pigment.

Wood Charcoal. This is made by charring wood. It is far from pure, but contains a much larger proportion of carbon than does animal charcoal. The time-honoured way of preparing it is by piling the wood in a heap, covering it over with turf, and then setting it on fire. The result is a number of lumps of wood charcoal which retain the original shape of the pieces of wood. It is an ingredient of old-fashioned gunpowder, mixed with sulphur and nitre or saltpetre, the nitrate of potassium. This form of carbon has a peculiar physical property; it is extremely porous, and thus will hold a large quantity of gas; but more than that, it has a power, hitherto unexplained, of condensing gases on its surface and in its substance. A given quantity of wood charcoal will absorb or occlude an amount of gas which would otherwise occupy hundreds of times its own volume. Wood charcoal is thus a deodorant, having the power of removing bad smells; but it is also in little measure a disinfectant, for it accumulates oxygen in its pores in a highly condensed and therefore very active form, by which means it is enabled, so to speak, to burn up microbes and bring their life to an end.

Gas Carbon. Another variety is gas carbon—porous, greyish black, and exceedingly hard—which is deposited in gas retorts during the process of making gas from coal. The coal gas consists largely of compounds of hydrogen and carbon, and it is from these that gas carbon is obtained. It also is amorphous.

Coal. Coal is one of the most important forms of carbon, of which it contains from about 70 per cent. in the poorest forms of coal up to 97 per cent. in anthracite. Anthracite coal is a direct product of the activity of chlorophyll, the substance which we mentioned in the last section. It consists of the carbon remains of certain forms of giant ferns which flourished upon certain portions of the earth's surface many geological ages ago. Coal is the characteristic constituent of the geological stratum which is known as the carboniferous. [See GEOLOGY.] There is good scientific ground for the poetical description of coal as "buried sunshine"; for the activity of the chlorophyll, to which it owes its formation, depends entirely upon the action of sunlight. When coal is heated in the absence of air, as for instance in the manufacture of coal gas, we obtain not only the gas carbon which is deposited on the upper surfaces of the gas retorts, but also the product which we call coke. This by no means consists of pure carbon, but it is very much purer than coal in its natural state.

The briefest reference may be made to some very interesting experiments by Sir James Dewar upon the behaviour of the various forms of carbon at extremely low temperatures, especially in relation to their power, already referred to, of occluding gases. He finds that when charcoal, for instance, is immersed in liquid air, its power of gaseous absorption is extraordinarily increased. We have yet to reach the explanation of these and countless other facts, which belong to the new science of physical chemistry.

Oxides of Carbon. Carbon forms two compounds with oxygen, both of which are of great importance. The simplest is known as *carbon monoxide*, or *carbonic oxide*, and has the formula CO. It is an odourless, tasteless, colourless gas, and is produced in Nature when carbon is burnt with an amount of oxygen which does not suffice for its complete oxidation. For, when carbon is completely oxidised, there is produced the substance known as carbon dioxide, or carbonic acid, which has the formula CO_2. Carbonic oxide may also be formed by reduction of carbon dioxide by means of red-hot carbon, according to the equation

$$CO_2 + C = 2CO.$$

This process may be observed in a hot fire, and is of importance, because it occurs in coke stoves. In an ordinary fire, the coal which is near the front, and thus receives abundance of oxygen, undergoes complete combustion, and yields carbon dioxide; but as this gas passes backwards over the red-hot coal at the back of the fire it is reduced, according to the above equation, and yields carbon monoxide; but as this arises it meets with a better supply of oxygen, and is itself burnt, to form carbon dioxide again. It burns with a blue flame, which may be constantly seen in a very hot fire or a charcoal stove. The formation of carbon monoxide in this fashion used to be a very frequent cause of death abroad, where charcoal until recently was too often burnt in rooms insufficiently ventilated, and without a proper exit for the products of combustion.

Now, why is this gas poisonous? We are able to answer the question very precisely. Carbon monoxide is poisonous in a special sense, as carbon dioxide is not, because it is capable of combining with the hæmoglobin of the blood. Carbon monoxide forms a very firm chemical union with hæmoglobin, yielding a compound which has a very bright red colour, and gives a characteristic cherry-red tint to the blood. This compound is a very firm one, and it prevents the hæmoglobin of the blood thus occupied from performing its proper function of carrying the oxygen of the air from the lungs to the tissues. Thus the patient dies of a kind of suffocation. The especial danger of this gas is that its accumulation in a room offers no warning to the senses of smell or taste.

Carbonic Acid. We may as well at once admit that this is not really an accurate name for what should be more properly called carbon dioxide (CO_2). A more accurate name, often employed, but unfortunately calculated further to puzzle the student, is *carbonic anhydride*. The meaning of this last word must be explained. An anhydride (which really means *not water*) is an acid from which have been removed the elements which correspond to the constitution of water—that is, in the proportion of two atoms of hydrogen to one of oxygen. The name carbonic acid should properly be confined to the union of carbon dioxide and water.

If we combine the two formulæ, H_2O and CO_2, and write the product with the hydrogen first—as we usually write the name of an acid—we get the formula H_2CO_3, and it is this substance to which the name of carbonic acid should properly be confined. This substance is not a mere chemical fiction; it has a real existence, though it is very unstable. If carbon dioxide be dissolved in water, we find that this substance is present. In the first place, such water has a very faintly acid taste—the taste of soda-water; in the second place, it is like an acid in its action on litmus paper.

Litmus. Litmus is a vegetable substance which is prepared from certain lichens, and acts as an extremely delicate test for the presence of acids and alkalies. A solution of it in water, carefully prepared so that not a trace of free alkali or free acid is present, has a violet colour, and blotting-paper may be impregnated with it. If, now, such litmus paper, as it is called, be exposed to the faintest trace of free acid, it immediately turns red; but if to the faintest trace of free alkali, it immediately turns blue.

Carbon Dioxide. We are entitled to conclude, then, that the solution of carbon dioxide in water is more than a mere solution, and includes a true acid, H_2CO_3, to which, if we were to be strict, we should have to confine the name of carbonic acid; but as soon as the water is heated the acid is broken up, and carbon dioxide, or carbonic anhydride—we now see the reason for the name—is given off. The union is, in fact, a very unstable one.

This most important substance is a colourless gas, all but free from smell and taste, and is normally produced by the complete oxidation of carbon. This is true, whether the carbon be coal in the fireplace, or carbon combined in living tissues. Every visible living thing, from microbe up to man, incessantly produces carbon dioxide as the consequence of its life. The gas is found in coal-mines also, and as it will not support life it constitutes a source of great danger to the miner, who calls it *choke-damp*. It is also produced in mines as the result of explosions of another gas called *fire-damp*, and then the coal-miner calls it *after-damp*. The gas is heavier than air, and thus accumulates in the lowest parts of coal-mines, old wells, and the like. The most convenient test for ascertaining whether it is safe to descend a well, for instance, consists in lowering a lighted candle and seeing whether it will continue to burn in the atmosphere of the well. It will, of course, be at once extinguished if plunged into an atmosphere of carbon dioxide. Upon the weight of carbon

dioxide depends the singularly brutal form of scientific experiment which is performed, or used to be performed, at the Grotto del Cane, in Italy, where a layer of carbonic acid lies upon the floor of the cave. Thus, human beings can walk in with impunity, but dogs which are completely immersed in the carbonic acid promptly succumb. Hence the name of the place.

Carbon dioxide is produced when we heat or otherwise decompose a carbonate. This was the famous experiment of Joseph Black, whom we mentioned in our second chapter. He heated chalk, which we now know to consist of calcium carbonate, or carbonate of lime ($CaCO_3$), and showed that it was converted into quicklime whilst losing an "air" which had formerly been "fixed" in it. This he therefore called "fixed air." We now know that it is carbon dioxide. and we are able to write the simple equation which represents the decomposition:

$$CaCO_3 = CaO + CO_2$$

Precisely the same thing happens when a carbonate, such as carbonate of soda, is treated with a strong acid. The acid takes to itself the base of the carbonate, which in this case is sodium, and turns out carbonic acid, which immediately shows itself in the form of bubbles of gas.

Carbonic Acid and the Air. Carbonic acid occurs as a constant constituent of the atmosphere, to the extent of about ·04–·06 per cent. This latter quantity is regarded by hygienists as about the limit which should be set to the amount of this gas permitted to occur in inhabited air; at any rate, the "physiological amount," as it may be called, should barely exceed ·06 per cent. The presence of green plants is important in modifying the percentage of carbon dioxide in air. Flowers and plants are beneficial in a room in daylight, for they reduce the amount of carbonic acid in the air by means of the process which was briefly mentioned when we were discussing iron and chlorophyll; but at night they are powerless. Day and night, like every other living thing, plants breathe, taking in oxygen, giving out carbonic acid, and thus tending to vitiate the air. Under the influence of sunlight this familiar process is more than neutralised, so far as we are concerned, by the converse process, but at night the plant continues to breathe and consume the air, whereas its salutary function ceased at sundown. Therefore remove all plants and flowers from a bed-room at night. The simultaneous performance of two exactly opposite functions in the daytime is perhaps rather confusing. At any rate, our case is simple enough. Day and night we simply add to the carbonic acid in the air, nor can we regain the valuable carbon surrendered thereto, except through the mediation of the plant.

Supposed Accumulation of Carbonic Acid. Now, if we picture the entire surface of the earth, on which man is so rapidly increasing, and if we consider that every living thing is incessantly producing carbonic acid during its life, whilst the same gas is evolved from its remains after its death, it may seem probable that at length all the oxygen of the air will be used up and replaced by carbonic acid. The reverse action performed by the green plant in daylight could delay this accumulation, but could not arrest it. Thus the imagination has pictured the last survivor of the human race as gasping for air somewhere on the side of Mount Everest; while his fellow beings, both animal and vegetable, lay drowned beneath him in the rising sea of carbonic acid. But there has now been discovered a compensatory process. We have reason to believe that the percentage of carbonic acid in the air is practically constant everywhere, and at all times. This is a very fortunate circumstance, for our breathing entirely depends for its success upon the presence of a proper percentage of oxygen and a small enough percentage of carbonic acid in the respired air.

The Sea to the Rescue. There is every reason to believe that it is the sea which controls and keeps constant the amount of carbonic acid in the air. Sea-water contains a varying proportion of the carbonate and the bicarbonate of magnesium, the latter salt containing twice as much carbonic acid as the former. Now, the proportion of carbonate to bicarbonate varies with the percentage of carbonic acid in the air above the sea. When that percentage tends to rise, what is called the *partial pressure* of the carbonic acid in the air also tends to rise, and the result of raising this pressure is to drive the excess of carbonic acid into the carbonate of magnesium in the sea-water, turning it into bicarbonate. If, on the contrary, there be, let us say, a large forest near the sea, which tends to reduce the amount of carbonic acid in the air and so to lower its partial pressure, some of the bicarbonate of magnesium in the sea-water is decomposed into carbonate and carbonic acid, which latter is given back to the air, the balance being thus restored. Thus, in accordance with the laws of what modern physical chemistry calls *dissociation*, there is an automatic arrangement for regulating and keeping constant the amount of atmospheric carbonic acid. The fact that the percentage of carbonic acid is so constant in different places is easily explained by the incessant movements of the atmosphere. The percentage of this gas in the air of a great town certainly rises during the day, but when the fires go out the wind is soon able to restore the original state of things. This is one of the reasons why night air, despite the popular prejudice against it, is healthier than day air.

Solid Carbonic Acid. We have heard much lately about liquid air and even liquid hydrogen. We also know that Sir James Dewar has succeeded in even solidifying both air and hydrogen. The first gas to be solidified by the chemist was carbonic acid; by the application of sufficient cold and pressure it may be readily obtained as a substance which has all the appearances of snow. It is not too cold to be held for a short time in the hand when it is in this solid condition.

Elements Allied to Carbon. The list of elements which have certain resemblances to carbon includes *silicon*, *tin*, *lead*, all of considerable importance, and three rare elements, *titanium*, *zirconium*, and *thorium*, only the last of which is of any practical importance. It is the essential constituent of gas-mantles for incandescent lighting.

Silicon, as we have already seen, is exceedingly abundant in combination, but it is never found in the free state in Nature. It may be extracted from its double fluoride with potassium by means of metallic sodium, and then is obtained as a brown powder. But it may also be obtained in black six-sided plates, and therefore presents us with another illustration of allotropy. It is obtained in its crystalline form by dissolving the amorphous powder in molten zinc, and then allowing the solution to cool.

One atom of silicon combines with two of oxygen to form the very abundant compound *silica*, which has the formula SiO_2. Like carbon, silicon combines with hydrogen to form a gaseous compound, and many of the carbon compounds can be paralleled by similar compounds, which differ only in containing carbon instead of silicon. Just as we have carbonates, the foundation of which is CO_2, so there are silicates, the basis of which is SiO_2. Glass consists entirely of silicates, the nature of the base varying in different kinds of glass.

The silicate of sodium, which has the formula Na_2SiO_3—compare the carbonate of sodium, Na_2CO_3—goes by the name of water-glass, and is used in solution for the purpose of making wood and other substances fireproof. For a full discussion of the important substance GLASS the reader is referred to the special section dealing with that subject [see MANUFACTURES].

Here we need only note that Sir William Crookes, the new President of the Royal Society, has just completed some invaluable experiments with glass of varying chemical composition, which have enabled him to provide lenses for workers with glowing iron, etc., that will protect their eyes from the destruction of health and production of cataract, which is so common at present. Meanwhile, the latest news is that the men decline to be bothered with these glasses.

Tin. Tin occurs in Nature in the form of its oxide, which is called *tinstone* and has the formula SnO_2. It occurs in Cornwall, as the ancients seem to have known, and also in Australia and Mexico. [See METALS.] Tin forms two series of salts, the stannous and the stannic, the meaning of which terminations was explained in our consideration of iron. The stannous chloride has the formula $SnCl_2$, and is known as salts of tin. It is used in dyeing and other trades. Stannic chloride has the formula $SnCl_4$, and is also used in dyeing.

One of the most useful properties of tin is its power of forming alloys with other metals. Tin and lead form pewter and various other substances, such as solder and Britannia metal. Tin combined with copper also yields bronze, and what is called speculum metal, which is capable of taking a high polish, that renders it valuable in optical instruments. The chief use of tin is in the making of tin-plates.

Lead. Lead is an important metal to which lately new theoretical interest has been attached, since there is actually reason to suppose, as has been briefly mentioned, that it represents the last stage of the atomic evolution, an earlier stage of which is represented by radium. The most important ore of lead is sulphide, the common name of which is *galena*. [See METALS, page 1455.] Commercial lead almost always contains a small proportion of silver, which is now extracted. When pure, the metal is very soft, yielding even to the finger-nail.

Lead is not attacked at all by dry air, but it is soon dulled by moist air, owing to the formation of an oxide. Lead, of course, is very largely used for the making of pipes and cisterns, and it is a matter of importance to know the conditions under which such lead will be dissolved and carried away in water which may subsequently be drunk. Comparatively large *single* doses of the salts of this metal may be taken with entire impunity.

Thus, acute lead poisoning is one of the rarest of occurrences, but the minutest quantities contained in water which is drunk for a long period may give rise to chronic poisoning, which is unfortunately still exceedingly common, and very often fatal. Chronic lead poisoning also arises from carelessness, and often in spite of every care, on the part of workers in lead. The most important precaution which these workers can take is that of scrupulously washing the hands before eating. For obvious reasons, lead poisoning is frequently referred to as "painter's colic." The carbonate of lead ($PbCO_3$, white lead) is still unfortunately one of the commonest of pigments.

The Action of Water on Lead. Let us now carefully inquire into the conditions which determine the action of water on lead pipes and cisterns. Hard water, as it is called, will never cause lead poisoning, because it is incapable of dissolving any lead from the surfaces with which it comes in contact. Hard water always contains free calcium carbonate or calcium sulphate, as we saw in a previous chapter. It is only in the case of soft water that any danger of chronic lead poisoning through the water supply is to be anticipated. Such water usually contains certain organic acids which are derived from the soil, and may be conveniently included under the general term of humic acid—from the Latin *humus*, the soil. These acids are capable of dissolving lead from pipes or cisterns, and thus giving rise to lead poisoning. Soft water is thus a source of constant danger if used for drinking.

The chief oxide of lead is known as litharge, which has the formula PbO. Another oxide, Pb_3O_4, is known as *red lead*, and is a scarlet powder, which may be obtained by heating litharge. It is used as a pigment, and in making flint glass. When acetic acid acts upon litharge we obtain a white powder, which is the acetate, and which, owing to its sweet taste, is known as *sugar of lead*. It has some small uses in medicine for external application only.

The Nitrogen Group of Elements. We must now pass to an important group of five elements—namely, *nitrogen, phosphorus, arsenic, antimony,* and *bismuth.* Not only do these form a distinct group from the chemical point of view, utterly diverse though they are in physical characters, but they also form a recognisable group in the resemblance between their respective actions upon the human body. Much the most important of these elements is nitrogen, which constitutes about four-fifths of the air, and which must be dealt with in detail.

Nitrogen. *Nitrogen* is a colourless, odourless gas. We inhale it with every breath. It may be obtained in a relatively pure state by several means. For instance, if we pass a current of air through a glass tube filled with red-hot copper, the copper keeps the oxygen while the nitrogen passes on; or we may turn out nitrogen from one of its most familiar compounds, *ammonia,* by means of chlorine. Ammonia has the formula NH_3, and if we pass a current of chlorine through a strong solution of ammonia, the hydrogen combines with the chlorine to form hydrochloric acid, HCl; whilst the nitrogen escapes, and may easily be collected. Other processes also permit of the collection of this element in a pure state from the compounds known as nitrates, which occur abundantly in many parts of the earth. Nitrogen may also be obtained from the complicated organic bodies called proteins. This element is a constituent of protoplasm—the physical basis of life—and therefore occurs in every visible living thing, animal or vegetable, high or low. In marked contrast to its partner oxygen, nitrogen is a very inert substance, having little tendency to combine with other elements. It is scarcely necessary to say that it does not support life or combustion. Its most useful rôle in the atmosphere, according to our present knowledge, is that of diluting the oxygen. Nitrogen is peculiarly insoluble in water. Under suitable conditions it can be burnt or combined with oxygen. Such union occurs as the result of passing an electric spark through the air, and thus—owing to the electrical conditions of the atmosphere, the passage of lightning, and so forth—small proportions of these compounds are found in the atmosphere. The oxides of nitrogen are no less than five in number—as we said in a previous chapter—but of these only one need be further discussed here, and that is known as nitrous oxide, having the formula N_2O. Popularly, it is called *laughing-gas,* and it is of historic interest as the first substance used for the production of general anæsthesia for surgical operations. Its property depends upon its behaviour in relation to the hæmoglobin of the blood, with which it forms a loose compound. It is probable that no single case of death directly attributable to its use can be recorded. It has a faint odour, with which the reader is very likely familiar. Very different is the odour of some of the higher oxides of nitrogen, which cause extreme discomfort and choking.

Phosphorus. This element and the succeeding two in this group, *arsenic* and *antimony,* are often known as *metalloids,* since they have at least some of the properties which we usually associate with metals. There is no free phosphorus in Nature, but the element is found in many rocks and minerals, besides being the necessary ingredient of all but the very lowliest forms of protoplasm or living matter. The element is usually obtained by distilling phosphoric acid (which has the formula H_3PO_4) with carbon. When this mixture is heated to whiteness the phosphorus distils over, and is collected in warm water. The manufacture is not easy, for the element is very ready to unite with oxygen, and burns, forming offensive and dangerous white fumes; thus the element has to be preserved under water. If any moisture be present, phosphorus is phosphorescent, or luminous, in the dark, the cause of this phenomenon being the slow oxidation which occurs on its surface. This ordinary, or *yellow* phosphorus occurs in eight-sided crystals; but we have here another case of allotropy, for if ordinary phosphorus be heated beyond a certain temperature in a closed vessel, or be heated in a tube with a small quantity of iodine, it is converted into another form called *red* phosphorus, usually called amorphous phosphorus, since it is usually non-crystalline. Red phosphorus is not luminous in the dark, since it is not oxidised at ordinary temperatures; it does not catch fire at low temperatures, it is exceedingly insoluble, and in consequence it is quite non-poisonous, whereas ordinary phosphorus is a very dangerous poison, the limit of safety for a medicinal dose being estimated at about one-twentieth of a grain. The most important commercial use of phosphorus is in the manufacture of matches, the chief value of the element in this connection lying in the fact that it catches fire at low temperatures. The ordinary match has phosphorus on its tip; in the case of the safety-match phosphorus is placed on the box. Recent inquiries seem to show that phosphorus may be obtained in a non-poisonous form which is quite efficient for all the purposes of matches. As very substantial danger is attached to the manufacture of matches in which ordinary phosphorus is employed, it is to be hoped that the manufacture of such matches, being superfluous, will entirely cease.

The Oxides of Phosphorus. Phosphorus forms two oxides, which have the respective formulas P_2O_3 and P_2O_5. Like CO_2, each of these is an anhydride of an acid. We need not here go into details of the various acids compounded of hydrogen, phosphorus, and oxygen. Hypophosphorous acid most people have heard of by implication, since its salts—the hypophosphites—have a probably illusory reputation as tonics. The most important acid is known as phosphoric acid, and has the formula already stated. Its anhydride is P_2O_5, which has a great affinity for water, and is used in chemistry for the purpose of removing the last traces of water from substances which are required to be absolutely dry. The reader may be puzzled as to how it is that the anhydride of the acid contains more atoms of oxygen than the acid itself, which certainly looks absurd. In

order to solve this difficulty, we must double the formula of phosphoric acid, so that it reads $H_6P_2O_8$. If from this we take three molecules of water, we find that we have P_2O_5 left, according to the equation

$$H_6P_2O_8=3H_2O+P_2O_5.$$

The most important salt of phosphoric acid is one of the calcium salts. This phosphate of lime is an essential constituent of plants, and it is absolutely necessary to add it to the soil by one means or another if it is expected to have a continuance of good crops.

Arsenic. This element is occasionally found in the uncombined state, but more usually in the form of a sulphide, often in combination with sulphide of iron. It is most commonly prepared from the mineral known as *mispickel*, which is a combination of these two sulphides. When this ore is heated in earthen vessels, the arsenic comes over in a gaseous state, and can be condensed. Arsenic does not occur in the liquid state, but passes directly from the gaseous to the solid state. It is a steelish-grey solid, and is another example of allotropy. If formed by slow condensation, it has a metallic lustre, and is crystalline. If rapidly condensed on a cold surface, it occurs as a black, amorphous substance.

The reason why arsenic does not liquefy is that, under ordinary conditions, its boiling point is at a lower temperature than its melting point. But if the atmospheric pressure be raised, the boiling point is raised above the melting point, and then the element may be liquefied. Arsenic is used in the manufacture of shot, as it makes the lead harder, and also makes it more readily assume a spherical shape as it drops through the air, which is the process by which shot is made. Arsenic is very largely used in medicine in very minute doses, and there are certain conditions of the skin and other organs in which it is valuable.

The great student of drugs, Binz, of Bonn, in Germany, has suggested that it owes its virtues to the property of carrying oxygen from the blood to the tissues. The drug accumulates in the body, however, and must not be given continuously. In large doses, and in chronic poisoning, arsenic causes a series of toxic symptoms, which resemble those caused by phosphorus, its predecessor in the periodic group, and by antimony, its successor.

Antimony. This element is, perhaps, more closely allied to the metals than its predecessors. It occurs in Nature in the form of the sulphide, which has the formula Sb_2S_3. Pure antimony can readily be obtained from the sulphide by heating this ore with scrap-iron, which combines with the sulphur, while the antimony melts and may be collected from the bottom of the vessel in which the operation is conducted. This element is brittle, bluish-white, and crystalline, and melts at the comparatively low temperature of about 450° C. It is only acted upon by air when heated, and then forms the trioxide, which has the formula Sb_2O_3, corresponding to that of the sulphide. Alloyed with lead, antimony goes to form *type-metal*. Alloyed with lead and tin, it forms Britannia metal.

The introduction of this drug into medicine is usually attributed to Paracelsus, and the story goes—but we give it only for what it is worth—that the derivation of the name depends upon a certain occasion when he took the opportunity of experimenting with this drug on a community of monks, who were very much disturbed by its unpleasant properties. Hence the name *anti*, against, and *moine*, the French for monk. This element is now no longer employed in rational therapeutics—except that certain organic combinations of it (like salvarsan, an organic compound of arsenic) are now being experimented with. It has a direct antagonism to living matter, and is thus ranked, together with some other substances, such as prussic acid, as a *protoplasmic poison*. Its most characteristic action upon the human body is as an emetic, and its most familiar salt is the compound with tartaric acid, which is known as *tartar-emetic*.

Bismuth. We have been dealing with these substances in the order of their atomic weight. Bismuth is very heavy, its atomic weight being no less than 208. It is prepared from its sulphide in a similar fashion to antimony. This salt occurs in Cornwall, while the metal is found native in Saxony. It is of some use in the formation of alloys, for when mixed with lead and tin, and sometimes with cadmium, it forms an alloy which melts considerably below the temperature of boiling water, and expands when it solidifies. This is known as *fusible metal*.

Bismuth forms a couple of oxides BiO_3 and BiO_5, and from these there may be formed salts which are of no particular importance. Two salts of bismuth, however, of no particular interest to the chemist, are largely used in medicine. These are the carbonate and the subnitrate, of which the latter is much the more important. In the treatment of certain affections of the alimentary canal, the subnitrate has no equal. It owes its medicinal properties partly to its weight and its consistence, but chiefly to the fact that it gives off minute quantities of nitric acid just where they are wanted, and is thus indirectly a safe but powerful antiseptic. Commercial bismuth used to contain arsenic, and may also contain traces of the rare metals *selenium* and *tellurium*.

Most pharmacopœias contain a large number of preparations of bismuth, including a number of liquid preparations, which are supposed to act more quickly; but, as a matter of fact, these liquid preparations undergo change immediately after they are swallowed, insoluble salts of bismuth being at once thrown down, or *precipitated*, as chemists say.

We appear to have gone very far indeed from nitrogen, which was the first member of this group; nevertheless, the further we study the chemical and physical and physiological properties of these five elements, the more we are convinced that there must be a relation between them, the nature of which can be guessed in some measure by those who have studied the previous chapters of this course.

C. W. SALEEBY

THE COMING DOWN INTO EUROPE OF THE BARBARIAN HORDES OF ASIA AFTER THE FALL OF ROME

A RAID OF THE HUNS, THE ASIATIC RACE WHO INVADED EUROPE UNDER ATTILA

From the painting entitled "Attila," by U. Checa. From a photograph by E. Fiorillo, Paris

The Goths and the Huns. The Rise of the Franks. The Supplanting of the Roman State by the Romish Church

THE MIDDLE AGES IN THE WEST

When Constantine the Great died, the Roman world was theoretically Christian, so far at least that the state encouraged Christianity and discouraged, without persecuting, paganism. Society professed Christianity. An unsuccessful attempt was made by one of his successors, Julian, called the Apostate, to revive the worship of the old pagan gods in the light of Greek philosophy, but the attempt was a failure. Till almost the end of the century the Roman world was ruled by a single emperor, who had his headquarters at Constantinople. There were no more violent changes of succession effected by successful generals, though there were attempts in that direction.

But this state of things ended with the last vigorous single ruler, Theodosius, who died in 395. Even before that, one military leader after another in Gaul and in Britain had attempted to seize the empire, and set up an independent dominion, and in the course of these struggles Britain had been almost denuded of the Roman legions. Meanwhile, the Teutonic tribes were pressing more heavily than ever upon the borders. The Goths had crossed the Danube, and the Allemanni were pressing upon the Rhine.

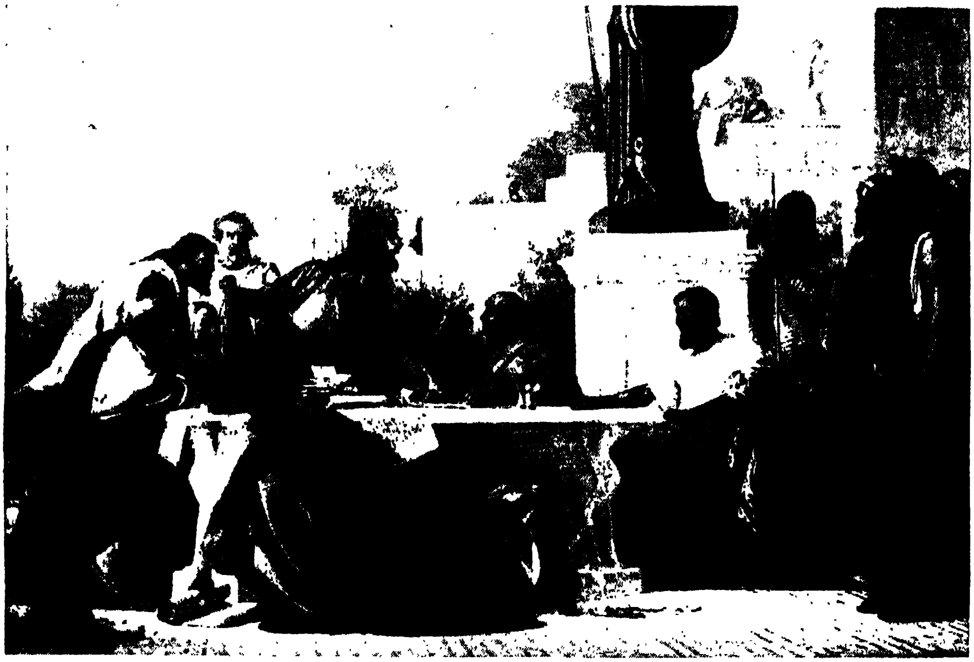
When Theodosius died, the empire was parted between his two sons—Honorius in the west, and Arcadius in the east. The Goths, under their great leader Alaric, diverted their attack from the eastern peninsula to Italy, but were for some time held in check by the great general Stilicho, himself a Teuton of the Vandal tribes akin to the Goths. The Vandals themselves burst over Gaul, and established themselves in Spain, where their name still survives in that of Andalusia. Stilicho fell under suspicion of treason, and was put to death by Honorius; then Alaric fell upon Italy, marched upon Rome, captured it, and sacked it, Honorius having retreated to Ravenna, thenceforth the real headquarters of the emperors in the west. This sack of Rome in 410 was the first since the Gauls had sacked it almost exactly eight hundred years before. The Goths and Vandals, it may be remarked, had nominally adopted Christianity, not in its orthodox form, but in the form known as Arianism, which virtually rejected the divinity of Christ.

Alaric the conqueror did not, however, choose to make himself emperor; the might of the Roman empire was still so impressive that he preferred to call himself the Commander of the Roman armies in the emperor's service. Almost immediately after the sack of Rome he died, and his successor, Athaulf, led the Goths out of Italy into Gaul and Spain, where they set up what is called the Visigothic, or West Gothic dominion. In the course of time they drove the Vandals out of Spain into Africa, where a Vandal kingdom was set up, still professing obedience to the Roman emperor.

Toward the middle of the fifth century new foes appeared. These were the Huns, a Mongolian or Tartar race from Central Asia, who under their mighty leader, Attila, first established themselves in Hungary (a name, however, which has no connection with "Hun"); then devastated all Central Europe, and burst into Gaul, where they were finally checked in a great battle at Chalons by the combined forces of the Roman general Æetius and the chief of the Visigoths. The barbarian tide—for the Huns were complete barbarians, unlike the Goths, who had absorbed much of the Roman culture—fell back, and after the death of their great leader Attila rolled away again altogether.

Long before this the last of the Roman legions had departed from Britain to take part in the last attempts of pretenders to the imperial throne. About the middle of the fifth century began the invasions of the British shores by the northern Teutonic tribes, Angles and Saxons, who for more than a century past had been infesting the North Sea. Another great group of German tribes, the Franks, had established themselves on the lower Rhine, in the north-east of Gaul. The so-called Roman armies in Italy itself were mostly composed of German mercenary soldiers gathered from every tribe.

At last in 479 a captain of the German troops in Italy, named Odoacer, deposed the western emperor, and made himself master of Italy, while professing himself the officer and the loyal subject of the eastern emperor at Constantinople, Zeno. Through all these years Italy had been in a state of chaos; at one time a Vandal fleet had entered the Tiber, and Rome had again been sacked. Odoacer restored the reign of order and law. But, in the meantime, one great division of the Goths had for a long time remained in its old quarters beyond the Danube. Latterly these Ostrogoths, or Eastern Goths, had passed over the Danube into the eastern empire, and now the eastern emperor, by no means satisfied with the doings of Odoacer, sought to get rid of them by turning the attention of their chief, the great Theodoric, to Italy. The whole people of the Ostrogoths, women and children as well as fighting men, poured through the north-eastern passes; Odoacer was defeated and assassinated, and at the close of the century Theodoric the Ostrogoth, a great ruler, was master of Italy.



THE EMPEROR JULIAN THE APOSTATE ADDRESSING A CONFERENCE OF CHRISTIANS
From the painting by Edward Armitage, A.R.A., in the Walker Art Gallery, Liverpool.

The Wisest King of the Barbarians. In the year 500 the leading states of Western Europe were those which had been founded by the two branches of the great Gothic nation, itself in many respects the most civilised and cultured of all the barbarian tribes that had built their homes amid the ruins of the Roman Empire. The West Goths, or Visigoths, under their king, Alaric II., the seventh in succession from his namesake, the ravager of Rome, occupied about three-quarters of the Spanish Peninsula and the whole of that beautiful region of Gaul which was known as Aquitaine, and which lay south and west of the broad sickle of the Loire. The East Goths, or Ostrogoths, ruled Italy and Sicily, as well as Germany up to the frontier of the Danube. Their king, Theodoric, was in many respects the wisest, strongest, and most enlightened of all the barbarian rulers, and honestly strove to blend as much as possible the culture of the old Greek and Roman world with the rough strength and energy of his Gothic countrymen.

Other Teutonic states were those of the Burgundians in the valley of the Rhone, of the Vandals along the northern coast of Africa, and of the Suevi in the region now called Portugal.

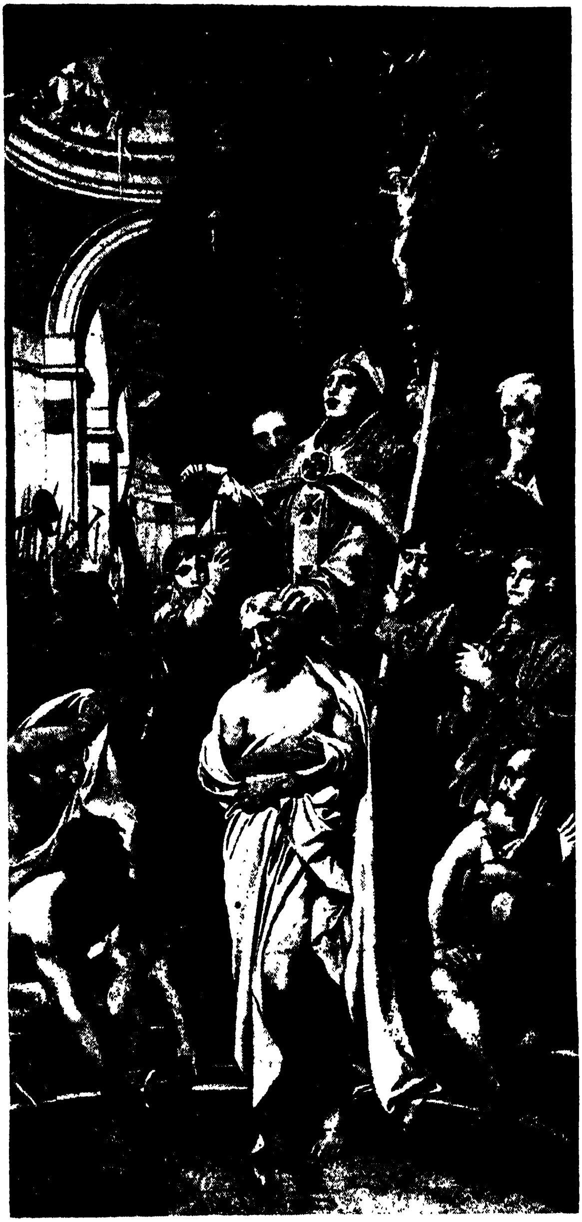
The Christianising of the Franks. All of these kingdoms were drawn together not only by a consciousness of kindred origin, but also by the profession of the same creed, for all had been converted to Christianity; but all were Christians of the Arian type, refusing to accept the statement in the Creed of Nicæa as to the co-equal divinity of Christ with His Father.

One Teutonic nationality, destined to be the mightiest of all, remains to be noticed. Along the mouths of the Rhine and the Meuse, in the flat expanses of Champagne and Lorraine, and on the left bank of the middle Rhine, clustered the two great divisions of the Frankish nation, the Salian and Ripuarian Franks. These fierce wielders of the battle-axe remained heathen long after most of their fellow-Teutons had accepted the message of Christianity; but four years before our story begins, their brisk young king, Chlodwig, or Clovis, embraced the faith of his Christian wife, Clotilde, and at his bidding the majority of his subjects embraced it likewise. A fact of immense importance for the future his-

tory of Gaul and of Europe was that the Christianity which won his allegiance was not of the Arian but of the Trinitarian or Catholic type.

This secured for him the hearty goodwill of the Catholic clergy, and through them of the subject Romanised population throughout the whole of Western Europe, and was doubtless one cause of the rapid extension of the Frankish kingdom. In the year 507, with the words, "I cannot endure that these Arians should hold so large a part of Gaul," he challenged the Visigothic king to battle, and defeated and slew him on the plains of Poitiers. The Visigothic monarchy lived on for a few centuries longer, south of the Pyrenees, and even extended its borders in 587 by the conquest of the Suevi, but, save for a narrow strip of territory, called Septimania, situated on the west coast of the Gulf of Lyons, its grasp on Gaul was completely gone.

Clovis and His Successors. Clovis died, a middle-aged man, in the year 511, but his sons continued his policy of profitable religious warfare, and after some campaigns, conducted with varying success, finally added the fruitful provinces of Burgundy to the Frankish kingdom, which now included the whole of modern France—save for the little strip of Septimanian territory—and also the Netherlands, the Rhinelands, and an indefinable extent of country beyond the Rhine. It was certainly in the six hundreds and seven hundreds (seventh and eighth centuries) the most powerful of all the barbarian kingdoms, but was weakened by the perpetual and, to a historian, most irritating partitions of the empire between the always jealous and often actively hostile members of the Royal Family—surnamed Merovingian, from Merovech, the fabled son of a sea-god and grandfather of Clovis.



THE BAPTISM OF CLOVIS

Changes in Religious Belief. Another source of weakness was the rapid demoralisation of the kings, whose constitutions were ruined by sensual indulgence, and who generally died before middle life, worn out by their vices. Thus, then, before the middle of the five hundreds two of the Arian kingdoms, the Burgundian and the Suevic, had been overthrown, and a third, the Visigothic, had been shorn of much of its strength. And before the five hundreds had run their course it, too, was lost to the Arian cause, not by conquest, but by conversion. In 587, Recared, the Visigothic king, who is believed by some to have been the first promulgator of the so-called Athanasian Creed, formally renounced Arianism, and the vast majority of his subjects made haste to follow his example.

Rome a Crippled Empire. While these events were happening in the west, the cause of Teutonic Arianism in Italy was sustaining deadly blows at the hands of an antagonist whom it had too lightly valued—the by no means effete though crippled Roman Empire. The wise and statesmanlike Theodoric, king of the Ostrogoths, died in 526, his last years having been clouded by rumours of conspiracy and sedition which had seduced him, naturally one of the most tolerant of rulers, into persecution of his Catholic subjects. A minority and a female regency followed. Theodoric's daughter, Amalasuntha, lost the

love of her Gothic warriors by her unwise following of Roman fashions; her son, the lad Athalaric, died of the excesses which followed on his liberation from her maternal strictness. The whole fair fabric of Italo-Gothic prosperity was shaken, but might perhaps yet have endured for generations had not the sceptre of the Byzantine Cæsars been swayed at this time by one of the most extraordinary of its possessors.

The Reign of Justinian. The story of the reign of Justinian (527-565) belongs to the eastern empire. By his brave and skilful general Belisarius he first overthrew the Vandal monarchy in Africa (533-535), and then successfully assaulted the Ostrogothic dominion in Italy. This last enterprise proved a far harder task than he had anticipated. Rome was taken and retaken three times; once for the space of forty days she lay absolutely empty of inhabitants. The struggle lasted sixteen years, and wore out the noble heart of Belisarius, who died, if not in poverty, in some measure of disgrace. But the stubborn patience of Justinian was at last rewarded with success. By the great victory which his old, wrinkled general Narses won amid the passes of the Apennines over the gallant young King Totila the last hope of the Ostrogoths was crushed. The remnant of that nation cleared out of Italy in 553, recrossed the Alps, and disappeared from history. Thus, then, by the middle of the five hundreds, or soon after, the whole of that powerful combination of peoples which had upheld the standard of Teutonic Arianism was dissolved. Some were exterminated, others were converted, and Catholicism was the religion of all, whether victors or vanquished. Let it not be thought that this was a matter of which only Church historians need take notice. Apart from all questions of theological soundness or unsoundness, the mere fact that the whole commonwealth of Western European nations professed the same creed and took their spiritual word of command from the Bishop of Rome exercised an enormous influence on the course of political history and national development from the downfall of the Arian kingdoms to the Reformation.

Rome's Missionary Enterprise. What made this extension of the spiritual sway of Rome more memorable was the splendid success of the missionary operations of the greatest of Roman pontiffs, Gregory I. (590-604). According to the well-known story, the sight of some handsome Anglian lads exposed for sale in the Forum caused him, in 596, to send his friend Augustine on a mission to the then almost forgotten and unknown island of Britain. Although Christianity of a somewhat different type retained its hold on the Keltic population, and might even be said to flourish in Ireland and in the Hebrides, the conversion of our stubborn Anglo-Saxon forefathers was not altogether an easy process, and, in fact, was not finally accomplished till the year 686, nearly a century after the landing of Augustine.

ST. AUGUSTINE PREACHING TO ETHELBERT AND HIS SAXON SUBJECTS

The Heroic Age of the Anglo-Saxons. This century, however, during which the struggle between Christianity and paganism was still going forward, was the heroic age of the Anglo-Saxon nation. Noble Christian kings, such as Edwin, Oswald, and Oswy, led their people upward in the path of civilisation. Even the obstinate pagan Penda was not without a strain of nobleness in his blood. Laymen and churchmen alike did more than lip-service to their new creed; and a man such as Bede, who was barely two generations removed from heathenism—he was born about 670—has won the abiding veneration of posterity both as saint and scholar.

The seven hundreds witnessed a melancholy decline in every department of Anglo-Saxon life. Murders of kings abounded, scholars were scarce, the monasteries became the haunts of the dissolute and the idle, but side by side with this decay of religious life at home there was a marvellous display of missionary energy abroad.

THE APPEAL OF THE CROSS TO BARBARIANS

BISHOP ST. LOUP APPEALING TO ATTILA TO SPARE THE TOWN OF TROYES

English Missionary Work. Wilfrid, Willibrord, Boniface, moved up and down through Friesland, Hesse, and Franconia, destroying idols and converting their worshippers. They were thus preparing the way for the addition of these regions beyond the Rhine to the vast Frankish empire. It is hardly too much to say that Germany owes both her Christianity and her civilisation to the labours of Anglo-Saxon missionaries.

From the statement previously made as to the unity of religious belief in Western Europe, two notable exceptions must, for a time, be made. They were caused by the arrival of the Lombards in Italy and of the Moors in Spain.

The Pope and the Lombards. Only fifteen years after the expulsion of the Ostrogoths from Italy, the Lombards, under their ruthless leader, Alboin, arrived in the peninsula (568). An uncouth and barbarous people, they were for generations a miserable substitute for the almost cultured Ostrogoths, and their religion, if they had any, was either Arian Christianity or absolute heathenism. Gregory the Great, even while he was planning his campaigns of spiritual conquest, was living, as he bitterly complained, "between the swords of the Lombards," and the fierce enmity between the Papacy and the Lombard kings was not appeased even by the conversion of the latter to Catholic Christianity, which was effected in a half-hearted, desultory way about a century after their entry into Italy. The conquest of Italy by the Lombards was only partial. From their capital at Pavia they ruled the greater part of the valley of the Po. Tuscany was theirs, and most of the country on the flanks of the Apennines, divided into the two great duchies of Spoleto and Benevento. But the city of Naples, the toe and heel of Italy, the island of Sicily, and—in the north-east corner of the land- the all but impregnable city of Ravenna still owed allegiance to the emperor, whose representative, called the exarch (generally a Byzantine courtier), ruled all imperial Italy from Ravenna as his capital. Rome was, of course, also nominally imperial; but all through these centuries the Popes, who had many a theological battle with the eastern emperor, were showing an increasing tendency to make Rome their own subject city, and to rule it independently of Constantinople.

THE SOJOURN OF THE GOTHS IN ITALY
From the painting by P. F. Poole, R.A., by permission of the Manchester Art Gallery.

The Rise of Venice. During the same period the little city, or group of cities, amid the mud-banks of the Adriatic, which was afterwards to be known as Venice, was quietly increasing in wealth and power, holding the Lombard barbarians at bay and professing unbounded loyalty to the distant Byzantine emperor. Visigothic and Catholic Spain underwent in the six hundreds a process of rapid decay. It was governed by kings, none of whom was able to found an abiding dynasty; by national councils, in which the power of the bishops, which directed the forces of the state chiefly to the persecution of Jews and heretics, predominated, and by nobles rich and turbulent, but destitute of loyal devotion to their country. The old Romanised population, of whom we hear but little, was probably oppressed and

THE CORONATION OF CHARLEMAGNE AT ROME IN THE YEAR 800

CHARLEMAGNE RECEIVING THE SUBMISSION OF WITTEKIND, THE SAXON, AT PADERBORN

downtrodden. Thus, when, in 711, the Saracen conquerors of Africa—who are generally styled Moors, though by no means all of Mauretanian descent—crossed the Straits of Gibraltar and challenged Roderic the king of the Goths, to a fight, one obstinately contested battle—that of Xeres de la Frontera—overthrew the whole rotten fabric of the Visigothic state. Save for a few resolute spirits who, under Pelayo, kept the standard of the Cross flying on the mountains of Asturias, all Spain was Moorish and Mussulman.

The Wave of Saracen Conquest. Nor did the wave of Saracen conquest stop with the Pyrenees. It flowed over into Gaul, and for a time seemed likely to add that country also to the empire of the caliphs. Fortunately for Europe, Charles Martel, the virtual ruler of the Franks, proved equal to the occasion, and in the desperately hard-fought battle of Poitiers—about seven miles from the modern city, often, but incorrectly, called the battle of Tours—defeated the Saracenic emir, Abd-er-Rahman, and saved Europe from the Moslem yoke. It is worthy of notice that this battle emphatically one of the decisive battles of the world—was fought in 732, exactly 100 years after the death of Mahomet, "Prophet of God."

Decay of the Merovingians. We have called Charles Martel "the virtual ruler of the Franks," for that, and not crowned king, was still the position of the members of the Arnulfing family, of which he was the head. For more than a century the kings of the Merovingian line had been sinking into a state of fatuous decline. Young men, for the most part ruined by dissipation, and seldom surviving their thirtieth year, they had allowed the reins of government to slip from their nerveless hands into the strong grasp of the chief minister, who was called mayor of the palace; and for three generations this fortunate manager of the royal business had been chosen from the same family, the descendants of the sainted Arnulf, Bishop of Metz.

Charles Martel, the greatest man whom the family had yet produced, and made incomparably greater by his deliverance of Europe from the infidel, died in 741, having never formally assumed the regal title. His sons, Carloman and Pippin, from motives of policy, thought proper to repeat the old comedy, and, drawing forth a descendant of Clovis from his seclusion, ordered him to reign as Childeric III. Before long, however, Carloman himself retired into a monastery, and Pippin, sole mayor of the palace, feeling his position now secure, addressed to Pope Zacharias the suggestive question whether it was better that the man who had all the power of a king or he, who had only the show of sovereignty, should reign. The Pope gave the answer which the wording of the question evidently implied, and, with his high sanction, Pippin was crowned and anointed king by the hands of Boniface, the missionary Bishop of Germany, about the year 751.

The Frankish king was soon able to show gratitude by important services to his papal benefactor. In the year 752 the king of the Lombards took the long impregnable Ravenna, and the dominion of the eastern emperor in the north of Italy came to an end. The triumphant Lombards pressed on toward Rome, and it seemed as if that imperial city itself would fall into their hands. Sorely pressed, Pope Stephen II., the successor of Zacharias, uttered plaintive appeals to Pippin for help, and even crossed the Alps in the depth of winter to urge his piteous case, and to gratify his patron by a second and solemn coronation. In two successive campaigns—755 and 756—Pippin vanquished the Lombard king, and compelled him to surrender the territories which he had conquered from the empire—known as the Exarchate and Pentapolis—to the Bishop of Rome. Thus was laid the foundation of the temporal lordship of the Popes over the territory known until the middle of the nineteenth century as the "States of the Church."

Charlemagne's Great Dominions. When Pippin died, in 768, his two sons, Charles and Carloman, succeeded without opposition to his royal inheritance. Carloman soon died, and Charles began that career of conquest and imperial organisation which has deservedly won for him the surname of Great, and has caused him to figure in countless poems of romance as the hero Charlemagne. In the first six years of his reign he conquered the Lombards and added the northern half of Italy to his dominions. In a long and stubborn conflict, which lasted thirty years, he subdued the barbarous Saxons, who dwelt in the modern province of Hanover, and forced them to accept the yoke of Christianity and civilisation. The yet more barbarous Avars, whose kingdom included at least half of modern Austria, were conquered before the end of the century; and the north-eastern corner of Spain was also won from the Moors. Thus the dominions of Charlemagne included all Europe west of the Elbe and the Danube, Italy as far as Naples, and Spain as far as the Ebro. There was no such splendid realm seen again in Europe till the days of the Emperor Napoleon.

Birth of the Holy Roman Empire. On Christmas Day, 800, the seal was set on all this glory by the coronation of Charles the Frank as Emperor of the Romans. Though for nearly four centuries the Roman Empire had been but a shadow as far as Western Europe was concerned, the memory of its greatness had never wholly faded out of the minds of men, nor had the people of the West ever heartily accepted the fiction that the true home of that empire was to be found at Constantinople. Now, when the Bishop of Rome had placed the imperial diadem on the head of the mightiest man of the mightiest nation in Europe, and when the citizens of Rome had cried with a loud voice, "Life and victory to Carolus Augustus, crowned by God, mighty and pacific emperor," it was felt that the waters of the barbarian deluge had indeed subsided, and the world had again a prospect of a peaceful and well-ordered life. Such was the second birth of "the Holy Roman Empire."

THOMAS HODGKIN

The Advantages and History of Reinforced Concrete. Use of Expanded Metal. Various Systems of Construction.

USES OF REINFORCED CONCRETE

Both on the Continent and in America the combination of concrete with iron or steel has for years past been employed for different kinds of structures, but until a few years ago the importance of this method of construction has not attracted the practical attention of engineers and architects in England which it deserves. Combinations of concrete with iron or steel are known by various names, such as "ferro-concrete," "armoured concrete," "concrete steel," "fortified concrete," and so on, but the name "reinforced concrete" is the term now generally accepted as covering all systems.

The Inventor of Reinforced Concrete. Perhaps the first use of reinforced concrete was in 1876, when M. Monier put into practice an invention for which he received a diploma at the Paris Exposition in 1878. As Monier's system became known, and the importance of his method of construction recognised, other systems sprang into existence, the outcome of various combinations of material; and at the present time some fifty exist, many evidently being brought out to avoid infringing patent rights. Some of these systems employ metal with peculiar sections. Others employ ordinary sections in peculiar positions. All, however, have the same object in view—that of placing the metal in such a position that it will take up the tensile stresses which the concrete is least able to deal with, leaving the concrete to take the compression stresses.

Construction in America. In America this "reinforced" concrete is used in the construction of office buildings of sixteen storeys, also for factories, railway stations, and similar structures, the foundations, walls, columns, girders, floors, and roof forming one monolithic mass. The Visintini system (introduced from Switzerland) employs girders of the Warren type, but of armoured concrete, made separately, and resting on brackets placed on armoured concrete columns. Across these main girders are similar, but shallower, girders, laid together and forming the floor. One manufacturing establishment built in this way is 200 ft. long and 50 ft. wide, having a middle row of columns. The main girders are 24 ft. long, 25 in. deep, 12½ ft. apart, and carry beams 12 ft. long and 6 in. deep, laid closely together. The girders and beams are composed of 1 part of Portland cement, 1½ of sand, and 3½ of broken trap rock, armoured or reinforced with ½ in. steel bars. The columns are composed of 1 of cement, 2 of sand, and 4 of broken stone; they have vertical 1 in. steel rods, connected by horizontal rectangular hoops of steel. Another system of concrete construction now being extensively use for residences, and for hotels, banks, and business buildings in the smaller towns, consists in the use of hollow concrete blocks, instead of bricks. These blocks are made in moulding-machines of various kinds, all sorts of moulds being used for ordinary blocks, lintels, sills, pillars, and architectural or ornamental shapes.

Concrete and Expanded Metal. The method of reinforcing concrete employed by the New Expanded Metal Company is that of placing sheets of mild steel vertically on edge, and with one operation slotting and drawing out the metal to the form shown in **1**. No loss of material or weight takes place. The expansion varies between six to twelve times the original length of the sheet, but there is no alteration in the width.

The resistance of the sheet before being expanded is 48,000 lb. per square inch. The ultimate strength of the metal when expanded is said to be increased up to 63,000 lb. per square inch. There is a loss of elasticity in the metal which is rather advantageous, as it is not advisable to have too elastic a substance.

The formula employed by the Expanded Metal Company for concrete slabs reinforced with expanded steel is as follows:

Safe working load in cwts. per square foot

$$\frac{6 \times t^2}{s^2}$$

where t = Thickness of slab in inches,

s = Span in feet from centre to centre of supports.

The sectional area of the expanded metal as compared with that of the concrete is in the proportion of 1 to 200.

Expanded metal is not adaptable to beams, so that where floors are being constructed on this principle the ordinary steel joists are employed. In cases where it is necessary to plaster the under side of the joists, or girders, the method of doing so is shown in **2**.

Use in Culverts, Conduits, and Bridges. Figs. **3** and **4** show the construction of a culvert with expanded metal reinforcing the concrete. Fig. **5** gives details of a reinforced concrete conduit.

Figs. **6** and **10** show a retaining wall constructed at West Hartlepool. This wall, though on the sea front, was not designed to withstand heavy sea-action.

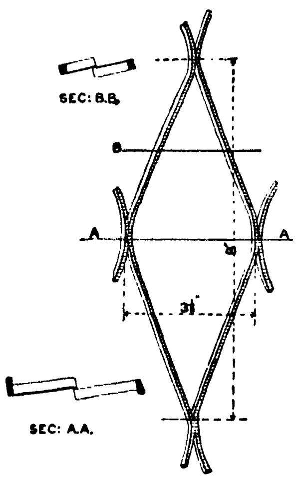
Figs. **12** and **13** show the employment of armoured concrete on a bridge constructed by Messrs. Wayss & Freytag over the river Ybbs. Fig. **12** shows the work in progress, and **13** is a view of the bridge when completed.

Piles constructed of reinforced concrete have been successfully employed. Their superiority to wooden piles consists in their being free from decay and attacks of insects. With regard to the destruction of wooden piles by insects, the

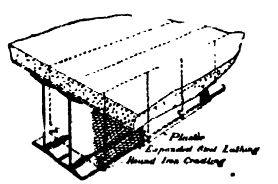
"teredo," or ship-worm, has been known to destroy a pile within twelve months. It has been found that in a comparatively short time 50 per cent. of the weight of the pile has been removed. The reinforced concrete pile, however, may be considered indestructible. Figs. **7, 8,** and **9** illustrate piles constructed on the Hennebique system. Fig. **11** shows the steel reinforcement ready for moulding with concrete as follows.

The piles are constructed in vertical timber moulds supported by frames, the inner section of the mould corresponding to the size and shape of each pile. The working face of the mould is left open, care being first taken to see that everything is perfectly plumb. The steel shoe is then inserted in the bottom of the mould, with its upper ends turned over inwardly to form a key to the concrete. The vertical rods are then placed in position, about an inch below the surface of the concrete, and connected together with distance pieces dropped from the top as required. Concreting is then begun, and the working face of the moulds is gradually closed with shuttering fixed about every six in. in height by the workman as he proceeds with the punning.

After about 38 hours the concrete is sufficiently set for the moulds to be stripped, and the piles are allowed to remain from 28 to 40 days to dry preparatory to driving. It is sometimes more economical and convenient to make the piles in horizontal moulds, but in that case the greatest care must be observed in obtaining the right consistency of concrete, so that in the punning operation the cement be not worked out too much to the upper surface.



1. EXPANDED METAL



2. EXPANDED METAL LATHING

Sheeting Piles. Fig. **7** is a typical example of a sheet pile in elevation and transverse sections, showing the disposition of the steel - work and drifted shoe. Fig. **8** is a plan of the same pile, showing the arrangement of the distance pieces, stirrups, and so on. These piles are fitted on each side with a semi-circular groove, which extends from the upper end of the shoe to the top of the pile ; and at the lower end of the pile, on its longer side, is fixed a metal spur which fits into the groove of the pile preceding it, and acts as a guide in driving. After driving, these grooves are carefully cleaned out by a water-jet and filled with cement grout, forming a solid watertight joint between the piling. These piles are made in lengths of 46 ft. and 48 ft., and have all the resiliency and elasticity of timber piles. As an instance of this, a 14 in. by 14 in. pile, 43 ft. long, suspended in the middle, will bear a deflection of from 3½ in. to 4 in., and, unlike timber piles, then can be easily lengthened and joined to the adjacent work.

The design of the pile is based on a calculation of the force to which it will be subject in the operation of driving, and the following formula enables this to be determined :

Let W = The safe load in tons.
Q = Weight of ram in tons.
f = Fall of ram in feet.

Then $W = Q \times 8\sqrt{f}$.

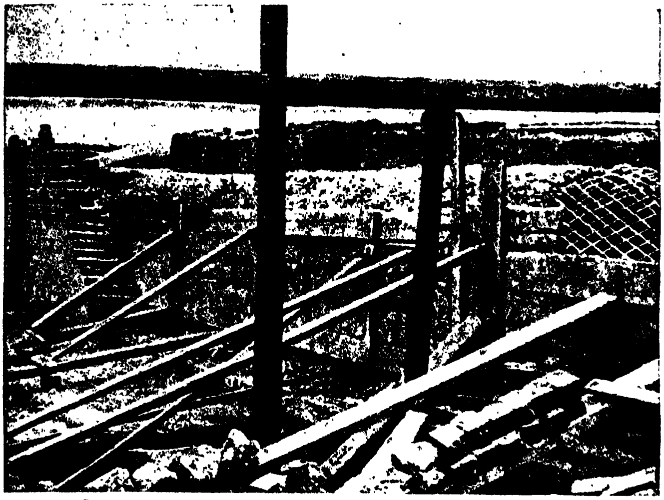
Pile Driving. Reinforced concrete piles can be driven either by hydraulic pressure or by the ordinary pile-driver. The best results, however, seemed to be obtained by employing a heavy monkey with a short drop. A helmet should be placed on the pile, with a space between the head of the pile and the helmet filled with sawdust.

Reinforced Concrete Columns. Until a few years ago reinforced concrete could not be economically employed for columns, as the compressive stresses were taken by the concrete alone, the safe limit of which varied between 500 and 600 lb. per square inch. By the invention of Mr. A. Considère, the French engineer, it is claimed that the safe limit for compression may be raised from 500 to 2500 lb. per square inch. This invention consists of reinforcing the concrete by metal spirals or "hoops," made by winding a metal bar round a drum or roller. The pitch of the rings of the spiral varies according to the diameter of the bar used, but is generally between 1½ in. to 3 in. Down the interior of the spiral are placed either four or six longitudinal bars bound at intervals to the spiral. These bars are employed to prevent bulging when the column is under compression. Fig. **14** shows the manner of reinforcing a column by this method. This column, it is stated, will carry a load of 90 tons, with a factor of safety of 5.

Piles constructed by this system have been employed for foundations on the banks of the River Seine. Fig. **15** shows the form used. They were 17 ft. long, driven by a 1·2 ton ram, with a drop of over 5 ft. The head of the pile was not, as with other systems, necessarily protected by a special cap, and only about six inches of the head of the pile, after being driven, had to be repaired.

The bridge at Plougastel is constructed of "armocrete," and the reinforcement is spiral or hooped. The bridge consists of two spans of 316 ft. 9 in., two of 106 ft. 7 in., and one of 52 ft. 3 in., making a total length of 895 ft.

Comparison with a Steel Joist. In comparing a beam constructed of reinforced concrete on the Hennebique system with a rolled joist, the steel rods which are placed in the lower part of the beam represent the line of



3. EXPANDED METAL FOR A CULVERT—SIDE VIEW

tension, and are acting similarly to the lower flange of a rolled joist [16]. Concrete is the material which is relied on to resist the compressive stress in the upper part of the beam, and the connection between the flanges as formed by the web (still comparing the beam to a rolled joist) is also formed of concrete, which, in addition, encases the tension bars and protects them against external agencies. Fig. 18 shows the form of the hoop-iron stirrups, which are distributed along the whole length of the beam, being embedded in the core of concrete, connecting the upper and lower parts of the beam, thus making a compact girder.

Tension Bars. The tension bars are of two kinds—namely, straight bars parallel to the lower face of the beam, and bent or cranked bars placed over them, but in the same vertical plane. The bent bars, taken in connection with the straight bars, and the stirrups (the latter being placed closer together at the ends of the beam), constitute an indeformable triangle, and the resistance afforded to shearing stress thus increases near the supports—that is, where the stress reaches its maximum.

A beam so formed is very similar to a timber beam trussed with iron tie-rods and brackets. Figs. 17 and 21 show the arrangement of a continuous Hennebique beam.

Fig. 21 shows the respective positions of the bars and stirrups, and how any bending stresses of the lower bars become transmitted by the stirrups to the upper part of the beam, and transformed and distributed in the way of compressive stresses in the mass of the concrete. Fig. 22 shows a cross-section through the beam.

An Armoured Concrete Floor. In order to divide up the component parts of a floor of any area that is supported by ferro-concrete beams, 20 shows the main beam constructed to receive the heaviest loads. Then comes the secondary beam, which is connected up to the main beam, and in turn receives a flat beam, which constitutes the floor. They are formed in a precisely similar manner to the other beams, and are calculated to support the required load.

In constructing an armoured concrete floor, the practice hitherto has been to erect, in the first instance, a complete wooden floor extending over the whole area proposed to be covered, and, after covering the floor with a thin layer of concrete, to lay down the steel rods on it, and then to complete the floor with the necessary thickness of concrete over the steel rods. This mode of construction necessitates the use of a large quantity of timber, which cannot be removed until after the concrete has set. The practical objections to it are the cost of the timber, the delay in its erection and removal, the hindrance to the rapid completion of the armoured concrete floor, and to its increased cost.

Armocrete Tubular Flooring. A system employed by the Armoured Concrete Construction Company, of Westminster, does

4. EXPANDED METAL FOR A CULVERT—END VIEW

away with these drawbacks by dividing the structure into three different parts—namely, the so-called webs (A), the tubes (B), and the concrete floor on top (C), as shown in **19**. The webs are made of concrete varying from 6 to 10 in. in depth, and in lengths up to 25 ft. They are reinforced with flat iron bars, *a a*, the thickness of the top layer C, and the sectional area of the armouring inserted in the webs being according to the load the floors have to carry. The tubes are made in 9 in. lengths of earthenware, stoneware, or concrete composed of coke-breeze or similar light material, and Portland cement.

When constructing a floor by this method, the workmen first place the webs in their proper positions (9 in. centres) without the help of any timbering, and the tubes are then put in. A floor is thus obtained. It is capable of carrying the weight of the workmen and materials stored on it. As soon as a certain area has thus been laid, a gang starts laying down the concrete (*c*) for the completion of the floor, the thickness varying from ½ in. to 3 in., according to the load to be carried. The reinforcement of the webs takes up the tensile stress, while the top part of the webs, together with the concrete flooring, takes up the compressive stress. The surface underneath may be plastered or left rough, according to requirements. The webs are manufactured in workshops as near the site as possible, and can be handled by two or three men, according to their length and weight.

The hollow tubes form a good insulation against change of temperature, and can be utilised as conduits for electric wires, or for water or steam pipes for heating purposes. The dead-weight of such floors is considerably less than many other forms of reinforced concrete floors.

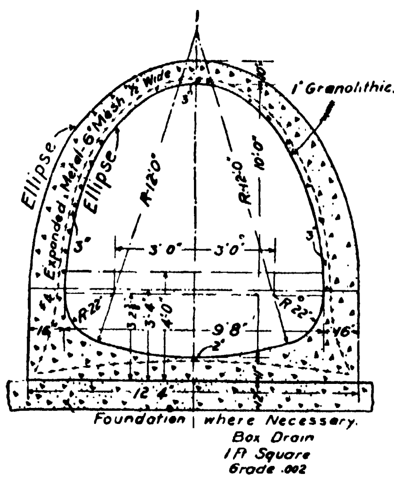
Roofs, if constructed of reinforced concrete, may be dealt with as floors, but in no part should the concrete be less than three inches thick.

Protection of Reinforcement. The reinforcement must not be placed nearer the face of the concrete than ½ in. in slabs, 1 in. in cross-beams, and 1½ in. in main beams and pillars. A distance of at least 1 in. must be left horizontally between the bars, and ½ in. vertically, except at points where the bars are in direct contact and transverse to one another. The maximum distance between the main tensile reinforcements of slabs must in no case be greater than 12 inches.

These rules, and others which have not been referred to, afford a basis for any legislation or by-laws which may be necessary to enable the advantages of this most important system to be utilised without the risks which would result from its employment by unskilful or ignorant persons. Several cases are known where unsatisfactory results have attended the unskilful use of reinforced concrete.

Estimating the Reinforcement. In determining the amount of metal necessary for reinforcing any particular structure, note must be taken of the quantity of cement to be employed in the concrete. The metal should have sufficient sectional area to sustain all the tensile stresses, but it should be observed that these stresses must not exceed the coefficient of elasticity of the concrete, or cracking will occur. The position of the bars is found from the fact that the value is in direct proportion to their distance from the neutral axis. The safe tensile stress for iron bars varies between six and seven tons per square inch.

The modulus of elasticity of steel may be taken as between 30,000,000 and 36,000,000 lb. per square inch, and that of concrete from 1,000,000 to 4,000,000 lb. per square inch, according to the amount of cement in the mixture. Another important factor is the amount of water used in mixing the concrete, as, should it be used too freely, a loss of elasticity occurs. It is necessary to have sufficient water for hydrating the cement, and for ordinary cement it may be taken that the best results are obtained by adding 4 to 4½ gallons to each cubic foot of cement used. It has been found that it is better to use the concrete fairly dry, and to ram it well into position round the metal.



5. EXPANDED METAL CONDUIT

Experiments show that concrete composed of cement, sand, and stone, or shingle is always stronger than that composed only of cement and sand. In addition to this, experience has shown that the strength of the concrete increases with its age.

Compression Limit. In reinforced concrete structures the safe limit for compression may be taken as 1450 lb. per square inch. This is the mean value after six weeks from moulding, and by allowing a further factor of safety of 3·5, the compressive resistance becomes 415 lb. per square inch. This figure is low when it is considered that experiments on large pieces show a resistance as high as 2510 to 3490 lb. per square inch at failure. Taking a safe limit at two-thirds of the final resistance, and allowing for the factor of safety 3·5, we get as safe stresses 665 lb. per square inch.

Taking everything into consideration, it is advisable to adopt 400 lb. per square inch for pieces in direct compression and reinforced with longitudinal bars tied with cross-pieces, and 500 lb. per square inch where pieces are to be subjected to bending. Where vibration is anticipated the figure is sometimes taken as 360 lb. per square inch. It must be borne in

mind that special cases require to be skilfully dealt with by the designer.

The resistance of concrete to shearing is taken as one-eighth of its resistance to compression—that is, about 50 lb. per square inch.

In calculating the tensile stresses to be taken by a reinforced concrete structure, the value of the resistance of the concrete is at present neglected. This is on the safe side, but when the behaviour and properties of reinforced concrete are better known, the tensile assistance due to the concrete may be taken into consideration.

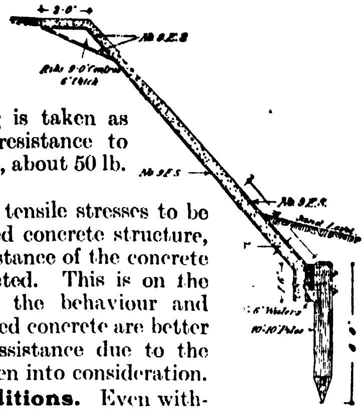
Essential Conditions. Even without State regulations, certain conditions must be strictly observed, otherwise failure will result.

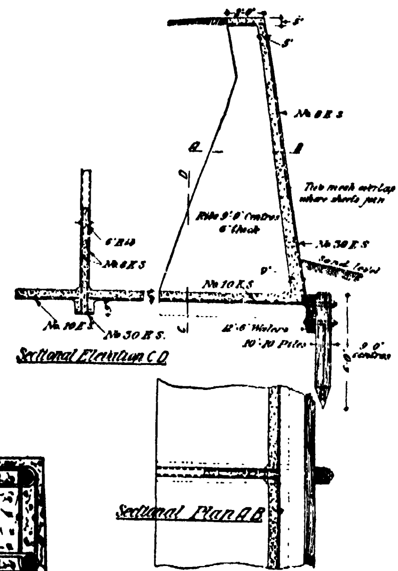
The quality of the materials to be used must be absolutely the best. The concrete must be made with Portland cement, and not inferior cement or lime.

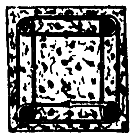
For watertight walls, tanks, conduits, pipes, or similar work the concrete must be made with sand and cement only, to assure impermeability, but where thickness is required as well as impermeability, the face-work can be made with rich mortar and a backing of concrete, not quite so richly gauged as the mortar. When pipes constructed of reinforced concrete are expected to stand high pressures, a lining of metal is used to prevent leakage. This, however, increases the cost of construction, making it sometimes more economical to employ ordinary steel or iron pipes.

It is necessary to see that the concrete is well rammed round the metal, so that no voids exist. Where large sections of metal are employed, it is advisable to paint all metal-work with cement grout before it is embedded, as by so doing the mass is made homogeneous—the metal being well cleaned previously. Another, and perhaps the best, reason for painting the metal before it is bedded is that, from experiments lasting over a number of years, it has been found that the surface of the metal is, by chemical action, covered with a coating of silicate of iron. This coating prevents rusting after the metal is embedded, and it has been found that rust existing previous to the embedding of the metal has been removed. This is of great importance, as at one time some doubt existed as to the life of reinforced concrete structures, especially those partially or wholly submerged.

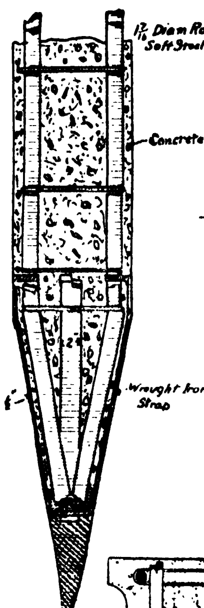
The Field of Reinforced Concrete. Reinforced concrete can be economically employed on bridges, buildings, floors, tanks, and similar structures, the cost of the work being lowered, while there is no loss of stability. It is essential that reinforced concrete must be designed, as well as carried out, scientifically, and, as before stated, only the best materials must be employed. Unscientific reinforcement produces waste of material, and may cause disastrous results. It is therefore necessary to attend minutely to every detail of construction.

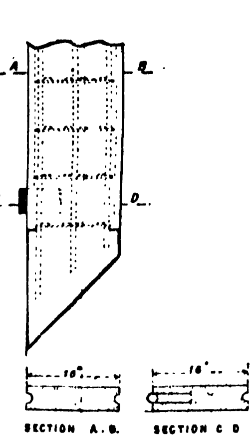




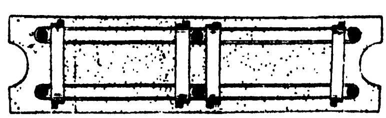


6. DETAIL OF WEST HARTLEPOOL SEA-WALL





7. FERRO-CONCRETE SHEETING PILE



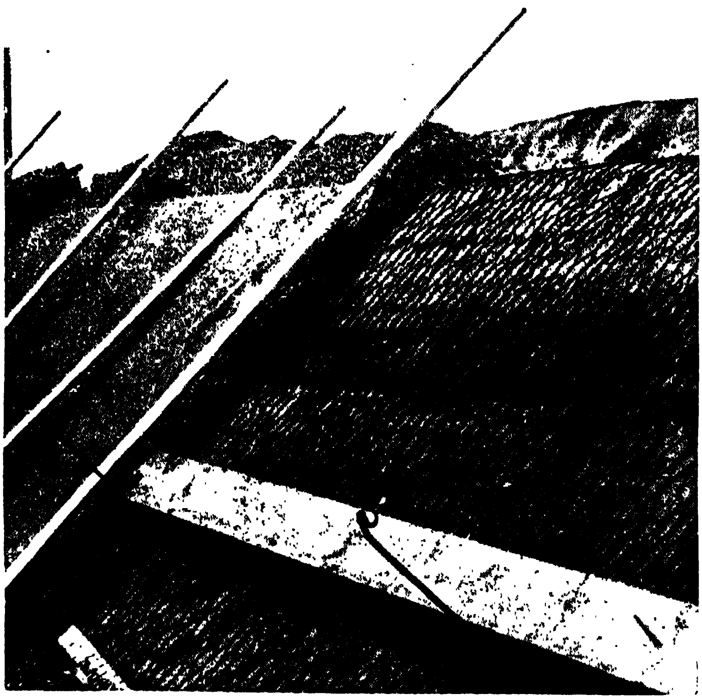
9. FERRO-CONCRETE PILE

8. FERRO-CONCRETE SHEETING PILE

Advantages of Reinforced Concrete. There are many advantages in the use of reinforced concrete. Perhaps the greatest one is that of economy in cost and rapidity in construction. By employing this system, large masses of concrete or masonry can be saved, without loss of stability, and the cost of maintenance is practically nil. Mouldings for bridges or buildings can be made without false work of any kind, and are often made on the ground,

being placed in position as the work proceeds. Lintels, sills, mullions, and other small framings are generally moulded prior to their being fixed in position, the rods being tied together with wire distance-pieces.

Structures of reinforced concrete are heavier for supporting the same load than those where iron or steel only is used. The hygienic value of structures made with reinforced concrete is indisputable, for they can easily be cleaned and disinfected, and do not harbour microbes. The fire-resisting properties of reinforced concrete have been proved beyond doubt, the low conductivity of the concrete protecting the metal from heating unduly. Buildings have been found to be as strong after a fierce fire as before,



10. WEST HARTLEPOOL SEA-WALL

practically the only repairs necessary being to fittings. The finer the mesh of the reinforcing metal in the floors and other parts of the building, the less the liability of the concrete to crack. Ordinary concrete rapidly disintegrates when subjected to sudden cooling, as when water is thrown upon it in times of fire. No such disintegration occurs with properly reinforced concrete. This is due to the coefficients of expansion of concrete and iron being practically the same, and therefore no internal stresses are set up by the differences of expansion or contraction.

Another great advantage of reinforced concrete is that it is free from decay due to damp, or the attacks of marine or other insects which cause so much damage to timber structures.

Resistance to Vibration. The resistance to shocks and vibrations is very marked, as will be seen from the following experiments.

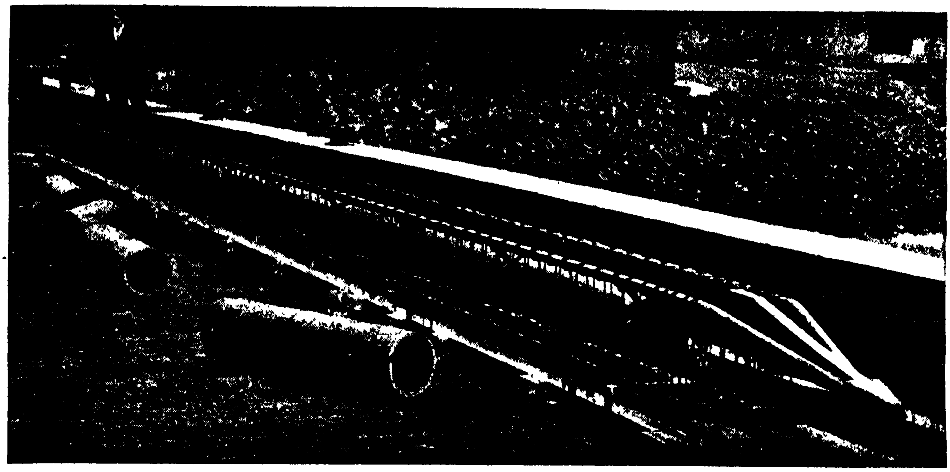
A weight of 112 lb. dropped 6 ft. 6 in. on an iron and brick floor produced vibrations $\frac{5}{16}$ in. in amplitude, lasting two seconds, while a weight 220 lb. dropped 13 ft. on a reinforced concrete floor produced vibrations $\frac{1}{16}$ in., lasting $\frac{4}{5}$ second. When floors are to stand shocks or vibrations it is necessary to increase the richness of the concrete.

Tanks constructed of reinforced concrete withstand the action of alkalies better than when constructed of timber, but free carbonic acid. nitric and hydrochloric acids have bad effects on the concrete. In cases where the solutions are weak, an increase of richness of the concrete overcomes this difficulty, but, where strong acids are prevalent, reinforced concrete pipes, and the like, should not be used. Hot fluids should never be turned into pipes made with reinforced concrete.

Influence of Atmospheric Action. Atmospheric action on reinforced concrete, such as humidity, causes elongation, while excessive dryness causes contraction. This action is more noticeable where the concrete has been made rich in cement. There is consequently a disadvantage in the employment of reinforced concrete in certain climates, applying more especially to exposed structures than to buildings or similar works. Timber expansion strips have been successfully used for retaining walls, but they cannot be employed for watertight work. Large arches and small bridges have been constructed with hinges on the abutments to overcome this difficulty. The high percentage of dead to live load prevents the employment of reinforced concrete for bridges of very large spans.

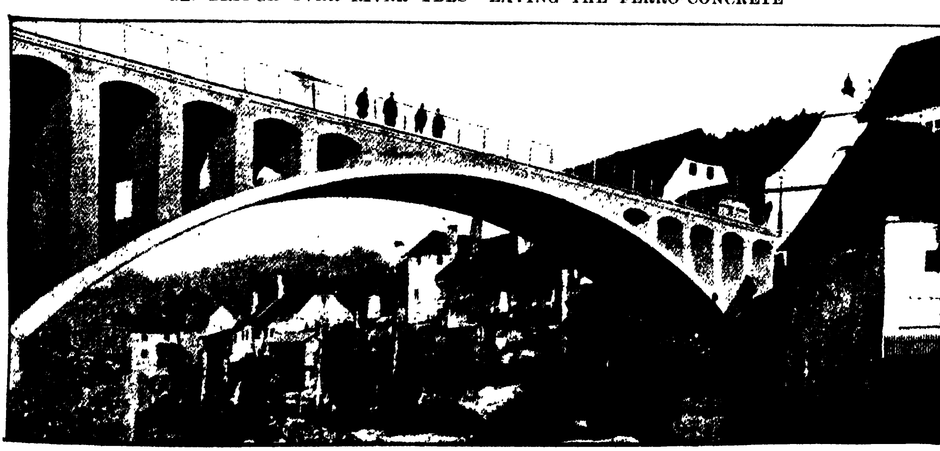
The greatest care must be taken when removing centring, struts, and props from the work after its completion. It is best to leave all shuttering, centres, and so on in position for several days, to allow the concrete to set thoroughly. The whole structure should remain for some weeks before any tests are applied to it. This period of rest is generally taken to be not less than four weeks, but it depends on the nature of the structure.

Fire-resisting Properties. The fire-resisting advantages of reinforced concrete must not be relied on unless certain conditions



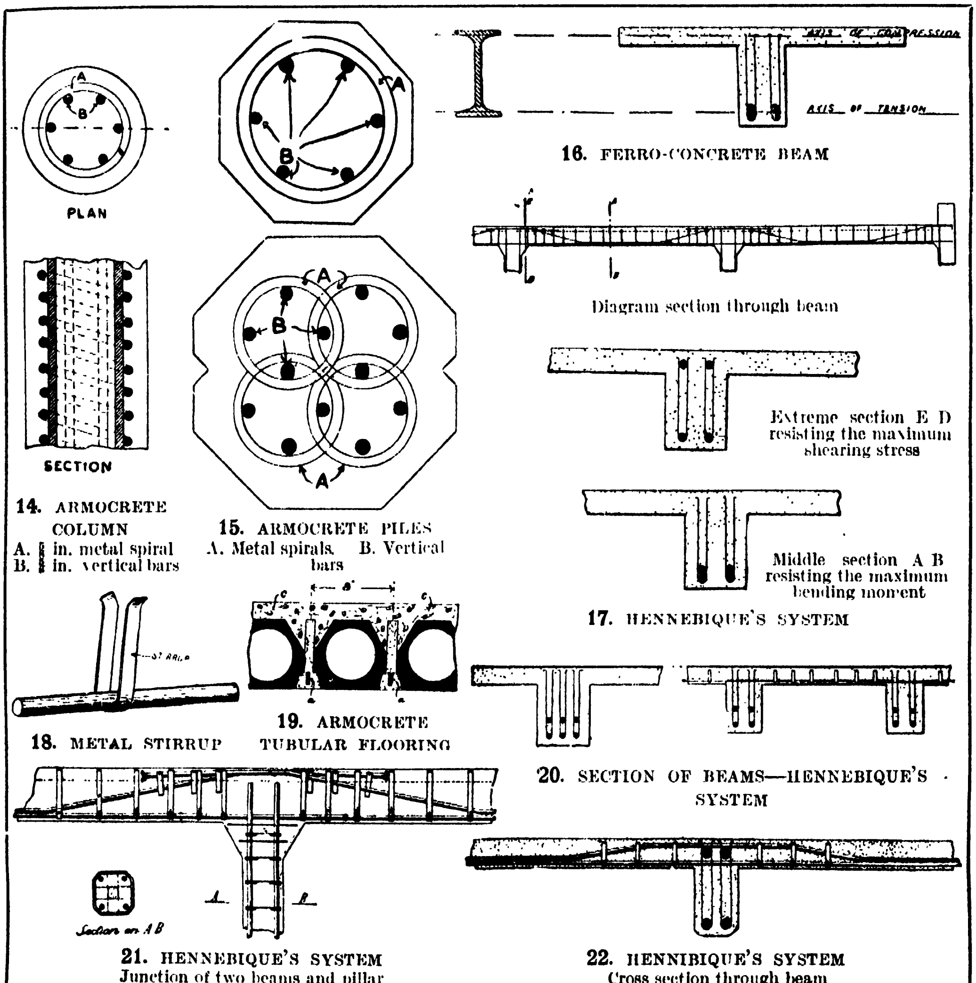
11. FERRO-CONCRETE PILE BEFORE MOULDING

12. BRIDGE OVER RIVER YBBS—LAYING THE FERRO-CONCRETE



13. BRIDGE OVER RIVER YBBS—COMPLETED

are observed, the neglect of which involves serious consequences. The main points for attention are the proper protection of the metal-work by embedding all rods and the like in suitable aggregate, and in making the aggregate of materials which are fire-resisting. The subject has received attention from the Fire Offices' Committee, who have issued rules defining the essentials to be observed to bring buildings constructed on this system within the insurance lines. The rules refer to embedded a ⅜ in. mesh, or of the aforementioned materials. It is also provided that the cement used should be Portland (equal to the latest British Standard Specification), in the proportion of 6 cwt. of cement to each cubic yard of concrete, and that the concrete must be thoroughly mixed, both dry and wet, and must be rammed round the metal-work in position. Every part of the metal-work must be closely encased in solid concrete. The rules require the external walls to be not less than 6 in., and



14. ARMOCRETE COLUMN
A. ⅜ in. metal spiral
B. ⅜ in. vertical bars

15. ARMOCRETE PILES
A. Metal spirals. B. Vertical bars

16. FERRO-CONCRETE BEAM

Diagram section through beam

Extreme section E D resisting the maximum shearing stress

Middle section A B resisting the maximum bending moment

17. HENNEBIQUE'S SYSTEM

18. METAL STIRRUP

19. ARMOCRETE TUBULAR FLOORING

20. SECTION OF BEAMS—HENNEBIQUE'S SYSTEM

21. HENNEBIQUE'S SYSTEM
Junction of two beams and pillar

22. HENNIBIQUE'S SYSTEM
Cross section through beam

14—22. COLUMNS AND BEAMS FOR FLOORING AND GENERAL BUILDING IN VARIOUS SYSTEMS OF ARMOURED CONCRETE

metal rods or bars spaced not more than 12 in. apart and overlapping at least 6 in. at all abutments and intersections, and having bands or bars across the concrete.

The rules of the Fire Offices also specify that walls and partitions must be of brick, terra-cotta, and cement concrete composed of broken brick, burnt ballast, furnace clinker, or similar hard or burnt material; that the concrete is to be composed of sand and gravel which will pass through party walls not less than 13 in., thick; that floors must be constructed of reinforced concrete not less than 5 in. thick in any part (no woodwork to be embedded therein), supported on beams or columns of similar reinforced concrete.

Official regulations for the use of this material are now being approved, and will shortly be issued, by the London County Council.

HENRY ROBINSON

A Short Study of Tennyson, with Briefer Notice of Browning, Swinburne, Matthew Arnold, and the lesser Victorian Poets.

TENNYSON AND AFTER

The Significance of Tennyson. Mr. Theodore Watts-Dunton, poet and a critic of poetry, has summed up the significance of Wordsworth's great successor in a single telling phrase. "Tennyson," he writes, "knew of but one justification for the thing he said—viz., that it was the thing he thought." ALFRED LORD TENNYSON (b. 1809; d. 1892) is the "bright, particular star" in the crowded galaxy of Victorian poets. His muse was responsive to the dreams of science and the doubts of philosophy, as to the whole world of Nature. One of the most scholarly and exact of poets since Milton and Gray, he was, with the possible exceptions of Burns and Byron, the most popular since Shakespeare. Not even Wordsworth took his vocation more seriously. From a period of idealism he passed to one of something very like pessimism. Always hating the petty conventions of the present, he became in his later years too much of a social critic for his poetry to benefit. From first to last, however, he was a master of word-music, acutely sensitive to every vibration in Nature, and capable of rendering his impressions with almost miraculous fidelity. He saw no less clearly than he heard. Proctor said there were no mistakes about the stars in his poems; and similar tributes have been paid to his knowledge of birds and flowers.

The value of Tennyson to the student is twofold. On the one hand, he teaches by example the qualities and possibilities of the English language; on the other hand, his poems may not inaptly be described as "the voice of the century" in all its modulations between the extremes of buoyant hope and desolate despair. "In Memoriam," his elegiac poem, written in memory of his friendship for Arthur Hallam, son of the historian, has been much misrepresented as an influence against orthodox religion. Tennyson's faith was firm and unshaken to the end, but "he dreaded the dogmatism of sects and rash definitions of God." "Locksley Hall," and its sequel, "Locksley Hall Sixty Years After," sum up the difference between liberal aspiration and democratic achievement. In "Maud," his favourite work, he entered an eloquent protest against material views of life.

The Poet's Views of Poetry. Tennyson's consistent contention was that poetry should be the flower and fruit of a man's life, and in every stage of it a worthy offering to the world. One day in the summer of 1888, in the garden of his home at Aldworth, Sussex, the Poet Laureate was discussing with Mr. Gosse the case of those who love to trace similarities, and seem to think that a mediocre poet who originates an idea is above the great poet who adopts and gives it everlasting form. Said Tennyson: "The dunces fancy it is the thought that makes poetry live. It isn't. It's the expression, the form; but we mustn't tell them so—they wouldn't know what we meant." This is a very different thing, of course, from saying that the "form" of poetry is its all in all, as the poet's further remark on the same occasion proves. "The highest poetry," he said, "may be popular, and praised in the magazines, and yet the secret of it is 'unrevealed to the whole godless world for ever.'" We may doubt if it is always revealed to the poet himself!

Tennyson and Modern Problems. If it be granted that Tennyson's poetry did not profit by his sensitiveness to the social problems of the time, or by the way in which he criticised the trend of policies and the fickleness of public opinion, it can hardly be gainsaid that he was a great teacher for all who care to give ear to his message. The best of Tennyson is not to be gathered by the pastime of hunting out plagiarisms from his poems. As the stirring events of Elizabeth's reign inspired Shakespeare, so was Tennyson inspired by the Battle of Waterloo and "the fairy tales of science" to the vision of a time when war-drums throbbed no longer—

> And the battle-flags were furl'd
> In the Parliament of man, the Federation of the world.

But he saw the peril, first of an excessive "John Bullism," and then of mere "talk." A poet of Nature, Tennyson was also a lover, if a critic, of humanity and a prophet of social reform. In his interpretation of the five chief subjects it has been the province of poets to deal with —Nature, woman, life, politics, and religion—Tennyson will be found always looking forward to the ultimate good. If the spirit of the present generation wars with Tennyson the teacher, it is because of his treatment, in "The Princess" particularly, of "woman's rights." His views on "the woman question" were, indeed, reactionary. "Woman," he wrote,

> is not undevelopt man,
> But diverse: could we make her as the man,
> Sweet Love were slain: his dearest bond is this,
> Not like to like, but like in difference.

The Metre of "In Memoriam." Tennyson is one of the most versatile of poets in his use of metre. "He realised," says Mr. Benson, "that the number of new thoughts that a writer can originate must be small—if, indeed, it is the province of a poet to originate thought at all—and the vital presentment, the crystalline concentration of ordinary experience is what he must aim at." Hence his close attention to "form." "He always held, as he says in his poem 'To Virgil,' that the hexameter was

the 'stateliest' metre ever invented; but he did not think it fit for English; he once said that it was only fit for comic subjects, and he believed that Englishmen confused accent with quantity. He indicated that quantity had so little existence in English that for practical purposes it was superseded by accent, and that, except for delicate effects, accent must be attended to; he always maintained that his experiments in classical metres had cost him more trouble than any of the poetry he had written." His son, the present Lord Tennyson, has an interesting chapter on "In Memoriam." The metre of this beautiful, if disjointed, elegy is the common long metre, with the second pair of rhymes indented. Here is a familiar example:

I held it truth, with him who sings
 To one clear harp in divers tones,
 That men may rise on stepping-stones
Of their dead selves to higher things.

Tennyson wrote: "As for the metre of 'In Memoriam,' I had no notion till 1880 that Lord Herbert of Cherbury had written his occasional verses in the same metre. I believed myself the originator of the metre until after 'In Memoriam' came out [in 1850], when someone told me that Ben Jonson and Sir Philip Sidney had used it."

Under the Spell of the Poet. A friend, writing to the author of the "Life," records a remarkable incident which binds Froude the historian and a ship's mate by a bond of human fellowship in their indebtedness to Tennyson's poetry. The incident is worthy of mention here as illustrating the power of the poet over readers of strangely different types. It is thus recorded in the official biography: "One moonlight night, when sailing, some years since, in the Malay Archipelago, I came on deck, to find the ship in charge of the mate, a taciturn mariner, uncouth, and of uncompromising visage. A chance remark, however, about the beauty of the night brought a line from a well-known stanza in 'In Memoriam' as reply. I completed the verse with undisguised pleasure, and this fairly broke the ice of his reserve. For the rest of that watch the mate paced up and down the deck, reciting to me the greater part of the 'Idylls' and the first half of 'Maud.' I shall never forget the feeling with which he lilted out the long 'Birds in the high Hall-garden.' During the next week—'all in the blue, unclouded weather' of that beautiful archipelago—the mate and I talked together on the one subject which had kept him, he averred, from suicide by drowning—a sailor's death more common than people think. For whole-heart delight in the poetry, for pure devotion to his image of the poet, I place that mate of a Malay coaster above all the Tennysonians I have met." Froude, writing in 1894, declared that he owed to Tennyson "the first serious reflections upon life and the nature of it," and that these had followed him for more than fifty years.

From a technical standpoint "Maud" is regarded by competent criticism as one of the most perfect of Tennyson's great poems; it is the one, moreover, of which the poet himself was specially fond. It contains the exquisite lyric "Come into the Garden, Maud." Perhaps the best of Tennyson's work was his earliest. That which penetrates the heart of the many is comprised in the lyrics, such as the song just referred to, together with "Break, Break, Break," "Sweet and Low," and his swan song, "Crossing the Bar." But the "Idylls of the King" are also widely loved. Mr. Benson places "The Lady of Shalott," "Mariana in the South," "The Miller's Daughter," "Œnone," "The Palace of Art," "The May Queen," "The Lotos Eaters," "A Dream of Fair Women," "The Morte d'Arthur," "Love and Duty," and "Locksley Hall" among the poems which have "profoundly affected English literature."

How to Study Tennyson. The best plan to pursue in the study of Tennyson is to take up the "Life" of the poet written by his son, and then to read the poems in the sequence in which they were written. Any student who will do this will know more of Tennyson (and, incidentally, of the most important of his contemporaries) than he will be able to glean from any other pair of volumes that can be named. For examples of (1) Tennyson's indebtedness to the writers who preceded him, and (2) the extent to which he re-wrote many of his poems, reference should be made to the "Illustrations of Tennyson" and "The Early Poems of Alfred Lord Tennyson," by Prof. Churton Collins.

Robert Browning. With ROBERT BROWNING (b. 1812; d. 1889) "form" was but a secondary consideration. Its requirements, in fact, constituted for him almost an obstacle to the flow of thought. He is as difficult and obscure as, for the most part, Tennyson is clear and easy to the common understanding. It is said that in the course of time Browning will supersede his great contemporary in popular estimation, but that time is not yet, nor likely to come soon. With Browning, far more than with Tennyson, it is necessary to consider the life and the poetry as interdependent and inter-explanatory. It has been well said that "much of the apparent obscurity of Browning is due to his habit of climbing up a precipice of thought, and then kicking away the ladder by which he climbed."

There is no gloom in Browning. He is all virility. His dramas and his poems are the appurtenances of an intellectual gymnasium. With Browning, "Life is—to wake, not sleep." "Rise and not rest," he cries; but "press—

From earth's level, where blindly creep
 Things perfected, more or less,
To the heaven's height, far and steep,
Where, amid what strifes and storms
 May wait the adventurous guest,
Power is love.

Tennyson wrote that:

'Tis better to have loved and lost
Than never to have loved at all.

With Browning it is better to have lived and struggled and failed than never to have lived.

Browning as a Poet. "Browning as a poet," writes that competent critic Prof. Dowden, "had his origins in the romantic school of English poetry; but he came at a time when the romance of external action and adventure had exhausted itself, and when it became necessary to carry romance into the inner world, where the adventures are those of the soul. On the ethical and religious side he sprang from English Puritanism. Each of these influences was modified by his own genius and by the circumstances of its development. His keen observation of facts and passionate inquisition of human character drew him in the direction of what is termed realism. . . . His Puritanism received important modifications from his wide-ranging artistic instincts and sympathies, and again from the liberality of a wide-ranging intellect. . . . He regarded our life on earth as a state of probation and of preparation. . . . In his methods Browning would acknowledge no master; he would please himself and compel his readers to accept his method, even if strange or singular. . . . His optimism was part of the vigorous sanity of his moral nature; like a reasonable man, he made the happiness which he did not find. . . . The emotions which he chiefly cared to interpret were those connected with religion, with art, and with the relations of the sexes.

. . . "His humour was robust, but seldom fine or delicate. . . . There is little repose in Browning's poetry. He feared lethargy of heart, the supine mood, more than he feared excess of passion. . . . His utterance, which is always vigorous, becomes intensely luminous at the needful points, and then relapses to its well-maintained vigour, a vigour not always accompanied by the highest poetical qualities. The music of his verse is entirely original, and so various are its kinds, so complex often are its effects, that it cannot be briefly characterised. Its attack upon the ear is often by surprises, which, corresponding to the sudden turns of thought and leaps of feeling, justify themselves as right and delightful. Yet he sometimes embarrasses his verse with an excess of suspensions and resolutions. Browning made many metrical experiments, some of which were unfortunate, but his failures are rather to be ascribed to temporary lapses into a misdirected ingenuity than to the absence of metrical feeling. His chief influence, other than what is purely artistic, upon a reader is towards establishing a connection between the known order of things in which we live and move, and that larger order of which it is a part."

An Important Point. It is especially important to remember that Browning's thought where it is most significant is often more or less enigmatical if taken by itself; "its energetic gestures, unless we see what they are directed against, seem aimless beating in the air." That portion of his work, therefore, which is primarily polemical bids fair to fail in interesting posterity. "Men and Women" includes some of his finest work, but his masterpiece is the living human epic of "The Ring and the Book." "How They Brought the Good News from Ghent," "Saul," "The Lost Leader," and "The Pied Piper of Hamelin" are among his most popular works. It is worthy of note, by the way, that the first book of "Selections from Browning" was issued at the request of a society of literary students meeting weekly in Whitechapel; and it would be no bad plan if the young student first approached Browning's poetry by the reading and re-reading of this admirable selection of his writings. It would prepare him in a measure for the strikingly individual qualities of the poet's longer works, and give him a good idea of the bent of Browning's mind.

Algernon Charles Swinburne (b. 1837; d. 1909). Swinburne's peculiar ideas, republican and agnostic, though popular opinion concerning them is to a certain extent misguided, most certainly had the effect of keeping the greatest modern lyrist from the Laureateship. In both his prose and his verse Swinburne seemed ever at the mercy of an irrepressible flow of language. He exaggerates whatever he touches. In the main, the exaggeration makes genuine poetry, if we consider poetry as devoid of all appeal except the appeal to the ear and the passions. But in some of his works, and notably in "Poems and Ballads," legitimate exaggeration ranges into regrettable licence, if not utter unintelligibility. Swinburne has yet to be recognised for his essential patriotism as he is admired for his songs of the sea. His verse is as near to actual music as that of any poet who ever lived. Reference has been made to Tennyson's facile use of varied metres, but in this regard Swinburne is the more comprehensive artist.

The More Important of the Minor Poets. Next in importance to Swinburne must be reckoned MATTHEW ARNOLD (b. 1822; d. 1888), whose poems, austere in form, classic in spirit, breathe the indefinable sadness of culture threatened by anarchy. Swinburne has uttered no criticism that rings more truly than his dictum that Matthew Arnold's "best essays ought to live longer than most; his poems cannot but live as long as any of their time." Matthew Arnold would have won lasting distinction among the few had he only written "The Strayed Reveller," "Empedocles on Etna," "The Scholar Gipsy," and "Sohrab and Rustum." The poems of FREDERICK TENNYSON (b. 1807; d. 1898) and CHARLES TENNYSON TURNER (b. 1808; d. 1879) may be studied with those of their illustrious brother. Frederick was joint author of the famous "Poems of Two Brothers," and his "Isles of Greece" is a poem well worth study. Charles is best represented by his sonnets.

The Rossettis. DANTE GABRIEL ROSSETTI (b. 1828; d. 1882) cannot, as Mr. Benson observes, be said to have modified in any direct way the great stream of English poetry but he "has stimulated the sense of beauty, the desire to extract the very essence of delight from emotion, form, and colour; he has inculcated

devotion to art." CHRISTINA ROSSETTI (b. 1830; d. 1894) takes a place in English literary history by the side of Mrs. Browning and JEAN INGELOW (b. 1820; d. 1897). RICHARD MONCKTON MILNES, LORD HOUGHTON (b. 1809; d. 1885), belongs to the school of Praed and F. LOCKER-LAMPSON (b. 1821; d. 1895) as a brilliant writer of society verse. WILLIAM E. AYTOUN (b. 1813; d. 1865) was the author of "Lays of the Scottish Cavaliers." AUBREY DE VERE (b. 1814; d. 1902), the son of Sir Aubrey de Vere, was, like his father, a successful sonneteer, but is more noteworthy as a critic and a friend of Tennyson. CHARLES MACKAY (b. 1814; d. 1889) wrote many well-known songs of the people.

A Polished Poem of a Lifetime. PHILIP JAMES BAILEY (b. 1816; d. 1902) spent his life in the development of his dramatic poem of "Festus," which, now half forgotten, was once hailed as the product of the highest poetic genius. JAMES WESTLAND MARSTON (b. 1820; d. 1890) wrote a number of dramas and poems that are but imperfectly remembered. Of his son, PHILIP BOURKE MARSTON (b. 1850; d. 1887), the blind poet, it may indeed be said that he learnt in suffering what he taught in song. Both JOHN RUSKIN (b. 1819; d. 1900) and GEORGE MEREDITH (b. 1828; d, 1909) are greater poets in their prose than in their verse. ARTHUR HUGH CLOUGH (b. 1819; d. 1861), as shown by "The Bothie of Tober-na-Vuolich," was not altogether given over to the philosophic doubt usually associated with his name. CHARLES KINGSLEY (b. 1819; d. 1875) should be praised for his "Andromeda" as well as for such lyrics as "O, that We Two were Maying," "The Sands of Dee," and "Three Fishers went Sailing," and his breezy "Ode to the North-East Wind." COVENTRY PATMORE (b. 1823; d. 1896) is seen at his best in the refined sympathy of "The Angel in the House" and "The Unknown Eros." In the Irish songs of WILLIAM ALLINGHAM (b. 1824; d. 1889) is to be traced something of the origin of the present "Celtic revival."

Stevenson, William Morris, and Francis Thompson. The poetic output of ROBERT LOUIS STEVENSON (b. 1850; d. 1894), limited in quantity, is notable in quality. GEORGE MACDONALD (b. 1824; d. 1905) wrote many short lyrics. His "Diary of an Old Soul" was declared by Ruskin to be one of the three great religious poems of the century. FRANCIS TURNER PALGRAVE (b. 1824; d. 1897) was greater as a critic than as a poet; his "Golden Treasury of Songs and Lyrics" bears witness to his powers of discrimination, though he owed much to the advice of Tennyson. GERALD MASSEY (b. 1828; d. 1907), the original of George Eliot's "Felix Holt," wrote poems expressive of the popular spirit which gave rise to Chartism. Sir EDWIN ARNOLD (b. 1832; d. 1904), in his "Light of Asia," interpreted Buddhism for Western readers. Sir LEWIS MORRIS (b. 1833; d. 1907), the author of "The Epic of Hades," an attempt to read the Greek myths in the light of Christian sentiment, "The Ode of Life," a review of life's stages, and "A Vision of Saints," monologues of men and women of saintly lives beginning with the Seven Sleepers of Ephesus and ending with Father Damien, was in his day the most popular poet next to Tennyson, whom, admittedly, he imitated. WILLIAM MORRIS (b. 1834; d. 1896) began in his "Earthly Paradise" by being "the idle singer of an empty day," and ended as the poetic singer of Socialism. Anglo-India inspired Sir FRANCIS HASTINGS DOYLE (b. 1810; d. 1888) and Sir ALFRED LYALL (b. 1835; d. 1911). JAMES THOMSON, "B. V." (b. 1834; d. 1882), depicted the dark side of London in "The City of Dreadful Night," and ranks among the unfortunates of genius. The same might almost be said of FRANCIS THOMPSON (b. 1859; d. 1907), the author of "The Hound of Heaven," whose style in verse is as original as Carlyle's in prose, and whose life has been told with pious devotion by his friend Mr. Wilfrid Meynell.

Vigorous Scots—Buchanan and Henley. ROBERT BUCHANAN (b. 1841; d. 1901) lost himself in controversy, but a selection of his poems, including his Ballads and "White Rose and Red," will have a second life. WILLIAM ERNEST HENLEY (b. 1849; d. 1903) will keep a distinctive place in Victorian literature. ALFRED AUSTIN (b. 1835; d. 1913) was unfortunate in challenging attention as Poet-Laureate at a time when his lyrical gift had failed him. Dr. RICHARD GARNETT (b. 1835; d. 1906) was a pleasing poet as well as a sound critic; and more may be said both in poetry and criticism of Mr. EDMUND GOSSE (b. 1849) and Mr. THEODORE WATTS-DUNTON (b. 1832). Mr. JOHN DAVIDSON (b. 1857; d. 1909) aspired to be the poet of evolution.

Some Notable Living Poets. Dr. ROBERT BRIDGES (b. 1844), the author of eight dramas of a classical type, as well as much delicately wrought verse, was acclaimed with widespread critical satisfaction Poet-Laureate in succession to Alfred Austin. Mr. RUDYARD KIPLING has greatly widened the bases of his reputation as a poet since the days of his "Barrack-room Ballads," and is the most vigorous force in the poetry of the period. Like Mr. WILLIAM WATSON (who in his "Wordworth's Grave" showed that it is possible to combine true poetry with criticism), Mr. Kipling has weakened his claim to a national standing by a political partisanship that only suits the newspapers. Other poets who must be mentioned are Mr. AUSTIN DOBSON (b. 1840), a graceful artist in verse; Mr. W. SCAWEN BLUNT (b. 1840), a powerful sonneteer; Mr. W. B. YEATS (b. 1865), whose verse has caught the glamour of the Irish race; Mr. HENRY NEWBOLT (b. 1862), master of a fine patriotic strain; Mr. JOHN MASEFIELD, a poet who raises great expectations; Mr. STEPHEN PHILLIPS, who alone brings modern poetical drama to the test of the stage; Mrs. ALICE MEYNELL, one of the greatest women writers of the age, with an individual and memorable voice; and Sir OWEN SEAMAN, who has the art of moving elegy as well as graceful mirth and parody.

J. A. HAMMERTON

The Education Acts and Authorities. Teaching Staffs in London and Provinces. Salaries and Promotion. Technical Colleges.

POSTS IN THE EDUCATIONAL ARMY

EVERY person of alert intelligence recognises today the intimate relation existing between efficiency and training, whether viewed from the personal or the national standpoint. It is unnecessary, therefore, to insist at length on the vast importance of popular education, and the responsibilities of those into whose hands such a vital trust is committed. In England and Wales modern legislation has confided most of this power to the greater municipal authorities, who have shown themselves worthy of the gigantic task; and there is perhaps no single department of local government work which can compare with it in essential value.

Two outstanding features in municipal control call for special notice. The first is that education throughout the country has been unified for the first time. The second and even more important fact is that every clever, studious child in the elementary schools—no matter how poor the parents may be—is now given an opportunity of obtaining a first-class education free of cost, and of securing in the same fashion a well-paid post as a teacher under the local authority.

These results have been achieved by means of the Education Acts of 1902 and 1903, the first of which affected all England and Wales save London only, and the latter the capital itself. Their effect was to transfer the board schools, or "provided" schools, to the local authorities, and to bring secular education in the voluntary or denominational schools under the same control. This last step, in particular, has done much for efficiency by reducing the number of untrained and poorly paid teachers in voluntary schools.

In the words of an educational expert "the Acts produced not so much a change as a revolution in our system of national education. At one stroke the elaborate machinery of school boards elected to deal with elementary education was wiped out of existence, educational interests of all kinds—elementary, secondary, and higher—were co-ordinated, and the power of control was invested in the municipal authorities throughout the country."

In this way the ancient breach dividing the elementary from the secondary school and the university was closed at last; and a carefully graded scheme of scholarships has welded the several systems into a single effective instrument of national education.

Some idea of the magnitude of the labours thus devolving on municipal bodies who were made education authorities by these Acts may be gathered from the latest educational returns. These show the number of elementary schools under inspection in England and Wales to be 21,294, with accommodation for nearly 7,000,000 scholars, and a total of 6,067,075 children on the books. The task of educating this mighty army of scholars is entrusted to 163,323 teachers, and costs the country considerably more than fourteen millions sterling every year.

These figures, it should be noted, relate to primary education alone. To the duties they denote must be added "the general co-ordination of all forms of education"—involving the maintenance and management of municipal secondary schools and technical colleges, the training of teachers, and the creation of an adequate "ladder of learning" by means of council scholarships to higher grade schools and the universities. As an instance of the liberal way in which this last obligation has been interpreted by the authorities concerned, it may be mentioned that in London alone over 3000 scholarships are now offered for competition every year.

The statute of 1902 created provincial education authorities of three grades, under the general control of the Board of Education. County councils and county borough councils have full powers for the purposes of the Act; while boroughs numbering over 10,000 inhabitants, and urban districts of above

20,000, have charge of elementary instruction only. The education authorities thus formed are distributed in the following way:

62	counties
75	county boroughs
134	larger boroughs
50	larger urban districts
321	

The Act of 1903 added but one new member to this list—the London County Council, which is the sole educational authority within its area. There are also a number of "minor local authorities," comprising 109 boroughs and 749 urban districts, with powers restricted to the levying of a rate for higher education.

Each authority acts through an education committee, appointed mainly by itself from its own ranks. In London no fewer than 38 members in a committee of 50 are County Councillors. These delegate bodies are invested with wide executive and advisory powers; but the local authority may disregard the advice of its committee, and remains subject in supreme control only to the mandates of the Education Board.

The Teaching Staff. The position of municipalities as education authorities being thus indicated, we may turn to consider the nature of the employment they offer in this capacity. It is noteworthy, by the way, that the local council appoints the staff of its provided schools, and that its consent is required to the appointments made by the managers in non-provided schools.

A recent report of the Board of Education affords some interesting information as to the numbers and pay of the teachers in municipal schools in this country. The teaching staff is constituted as follows:

	Male	Female
Certificated teachers ..	31,214 ..	63,574
Uncertificated, supplementary, and student teachers..	5,808 ..	49,389
	37,022	112,963

The average salaries of the *certificated* teachers in English public elementary schools, and the marked upward trend of salaries during recent years, are shown in the following table.

Average Annual Salary	Masters. Head.	Masters. Assistant.	Mistresses. Head.	Mistresses. Assistant.
1903-4	£156 11 6	£112 4 4	£104 0 1	£80 15 4
1910-11	£176 3 11	£127 9 11	£122 18 1	£92 8 6

A detailed account of the conditions of service under each of the 321 educational authorities—the salaries they pay and the qualifications they demand of teachers of every grade—would fill a bulky volume. These particulars can generally be obtained in respect of any single area from the secretary to the education committee of the local council concerned. Our purpose in the present chapter will be served best by reviewing at some length the methods of a typical council, and adding whatever comments are requisite as to the educational service generally.

The London County Council. The choice of an authority need not detain us for a moment, for London possesses in its County Council by far the greatest and most influential of them all. The explanation is that the sway of other county councils is broken by the occurrence of county boroughs and less important education authorities within their area. The London County Council, however, under the terms of its own special Education Act (that of 1903), is supreme throughout the length and breadth of its district. As Pope said of Addison, it "bears, like the Turk, no rival near the throne."

London's Educational Army. The Council's Education Committee, according to the last available returns, has charge of 550 provided and 364 non-provided primary schools, with a total average attendance of 650,568 children, and a teaching staff that numbers 18,039. It also controls the most efficient set of special schools in the kingdom, comprising centres for manual training, wood and metal work and household duties, institutions for mentally and physically defective scholars, industrial and truant schools, technical institutes, and twelve training colleges. The committee is also giving effect, at an annual cost of £260,805, to the elaborate system of scholarships already mentioned, which is designed to afford every capable child in London an opportunity of securing a thorough education free of charge.

Free Training for Teachers. The London County Council has devised a complete and generous system of scholarships, by means of which the most promising pupils in its elementary schools may gain a free course of training that will qualify them for posts on the Council's teaching staff. An avenue of escape is thus offered from ill-paid drudgery and "blind alley" occupations; and the education authority also profits, as the scheme assures a supply of clever and well-trained teachers.

The first step in the future teacher's career is to secure one of the 1700 junior scholarships offered yearly to elementary pupils of the age of eleven. The test for these awards is in English and arithmetic. The scholarships provide free education in a secondary school for three years at least, and are generally extended to five years. There are also intermediate awards, by which the free schooling is continued to the age of 18 or 19.

On reaching the age of 16, pupils desiring to become teachers are eligible for bursaries. These carry a year's free education, and a money grant as well if the parents' income is not over £300. During the year, bursars are prepared for the entrance examination for training colleges.

Bursars and other pupils at secondary schools, when 17 years of age, may apply for student teacherships. These are tenable for one year,

and carry a maintenance grant of £55 for boys and £30 for girls. At the expiry of the year, students whose progress has been satisfactory are admitted to a course of two years' free tuition in one of the Council's training colleges, male students receiving a grant of £25 a year meanwhile, and women £20 a year. They then receive the certificate of the Board of Education, and are eligible for posts in the Council's schools.

There are also a number of special scholarships awarded annually for technical and trade instruction, including courses of training for women in domestic economy, and exhibitions to apprentices in various trades.

Fuller particulars of this liberal scheme will be found in the London County Council's "Handbook of Scholarships and Training of Teachers," price 3d. (post free) from Messrs. P. S. King & Son, 4, Great Smith Street, Westminster, S.W.

Salaries of Certificated Teachers. The salary of teachers who have had two years' training begins at £100 for men and £90 for women. In central and higher grade schools the rate is £10 a year extra. Certificated teachers holding a degree, or training for three years, receive an additional £10 yearly.

Men entering the Council's service without a college training start at £80, and women at £75 a year, but they rise to the same maximum as the rest. The annual increments are, in the case of men, £5 for the first two years, and £7 10s. thereafter, to a maximum of £200, subject to a special report on reaching £150; and, in the case of women, £4 to a maximum of £150, subject to a special report on reaching £130.

THE LONDON COUNTY COUNCIL EDUCATION OFFICES

Regulations for Promotion. To regulate the promotion of assistants to principal rank, the Council's Education Committee has adopted the system of framing an Annual Promotion List of selected names. When a head teacher's post becomes vacant, no application from an assistant is entertained unless his name is on the list. In this way the number of candidates for such positions is kept within practicable limits. Men are eligible for the list after ten years' service, and women after eight years, but in practice the average term before promotion is about 17 years.

Head Teachers. The salaries of head teachers in the London service are as given below. There are very few schools of Grade I.

Schools	Accommodation.	Men. Salary and annual increments.	Women. Salary and annual increments.
Elementary: Grade I.	1—200	£10 more than salary under scale for assistants (minimum, £150)	£10 more than salary under scale for assistants (minimum, £125)
„ II.	201—400	£200—£300 by £10	£150—£225 by £8
„ III.	401 and upwards	£300—£400 by £10	£225—£300 by £8
Central	·	£200—£400 by £10	£150—£300 by £8

The principals of pupil-teachers' centres, secondary schools, and technical colleges are more liberally remunerated, the average rates in London ranging from £500 to £750 a year. Such posts are frequently advertised, and attract candidates of considerable scholastic attainments and wide experience.

Instructors in special subjects, such as teachers of cookery, laundry work, and housewifery, must hold either first-class teaching diplomas in these subjects, from a recognised training school, or some higher qualification. They are paid £80 a year, rising by £5 yearly to £120. Drawing teachers of permanent rank are required, as a rule, to possess the art-master's certificate, to be capable of teaching clay modelling and elementary design, and to have had experience in teaching. The scale of salary for men is £175, advancing to £200, and for women a minimum of £125, and a maximum of £150. Instructors in metal-work and wood-work at day schools are, in some instances, trained at the Council's technical schools, entering as lads at 6s. a week, and advancing through assistant grades to the rank of instructor, with an initial salary of £100, and a maximum of £155 a year. These posts are sometimes offered to outside applicants at the above salary.

In centres for mentally and physically defective children, all certificated assistants receive £10 more than in ordinary schools, but are restricted to the same maximum. Male teachers of the blind, if uncertificated, begin at £90, and

rise to £140 a year; for women, if uncertificated, the limits are £70 and £115.

Evening Schools. Most of the teaching posts in the Council's evening schools are held by members of the day staff, who receive extra pay, varying from 4s. an evening up to £125 a year. A number of these posts, however, are open to other than officials, and are advertised in the daily Press. In art, science, and advanced commercial subjects the usual rate of pay for an evening of three hours is 10s. 6d. to instructors, and 7s. 6d. to their assistants.

The conditions of employment for all special teachers can be obtained on application to the Education Officer, L.C.C. Education Offices, Victoria Embankment, W.C. Information concerning them is also given from time to time in the official journal of the Council, "The London County Council Gazette," published weekly at 4, Great Smith Street, Westminster, S.W. To complete our survey of the Council's educational staff, two further classes of appointments should be noticed, whose duties are administrative and executive rather than concerned with teaching.

Chief Inspector's Branch. Vacancies in this branch are advertised as they occur. The salaries are as follow: Assistant inspectors, £250, rising by annual increments of £15 to £400 a year; district inspectors, £400, rising by £25 to £600 a year; divisional inspectors, £600, by £25 to £800 a year. There are also inspectorships of special subjects—namely, art, wood and metal work, domestic subjects, needlework, and so on—at salaries varying from £120 to £500 a year. Candidates for these appointments have to be specially qualified in the subject in which they are required to inspect.

There are no restrictions as to age or sex of candidates for any of these appointments; but as the officers appointed are required to assist the Council's district inspectors of day, evening, and technical schools, it need hardly be said that candidates should have some special qualifications for these duties.

The Visiting Staff. Some 350 visitors or attendance officers are employed in investigating cases of absence from school, interviewing parents, and otherwise checking truancy. Vacancies on this staff are usually advertised in the public Press or in the Council's own organ, above-mentioned. Applicants must be between the ages of 25 and 35 (40 in the case of non-commissioned officers in the Army and Navy, or members of the Police Force of not less rank than sergeant). From among those who are successful in an elementary educational test the vacancies are filled. Successful candidates must produce proof of age, and submit to a medical examination. Salaries in the divisional staff of visitors begin at £80 a year, and rise by £5 yearly to £156. There are a few women on the staff.

Notes on Provincial Authorities. As already indicated, London stands alone in the extent of its educational problem, and few other municipalities have framed a scheme of instruction which approaches that of the capital in completeness. Most of the leading authorities, however, are giving due effect to the provisions of the Education Act of 1902 respecting the training of teachers and the co-ordination of all grades of instruction. The number of teachers furnished by the older *régime* having proved generally insufficient under the new system, it has been necessary in many areas to establish other training colleges for pupil-teachers, and to promote an adequate supply of candidates by means of exhibitions, bursaries, and scholarships, as in London.

Local conditions in different parts of the country are responsible for many variations from the educational type displayed by the London scheme. In the agricultural districts, for instance, greater prominence is naturally given to such training as shall fit the senior scholars for successful cultivation of the land. Hence, the Councils of Lancashire, Hampshire, and other counties have established farm schools, in which pupils receive instruction in dairy farming and poultry rearing on a basis at once scientific and practical. In some instances the consent of the Board of Education has been obtained to the introduction of these subjects into elementary day-schools, children of 12 and upward learning farm and garden work for two or three afternoons each week.

Technical Colleges. In the great manufacturing and industrial centres, on the other hand, where workshops and factories absorb most of the pupils leaving school, technical training is correspondingly developed.

Evening classes and polytechnics afford instruction not only in applied science but also in industrial subjects—dyeing and bleaching, bookbinding, weaving, and similar work. The experts who teach these studies are generally well paid. The educational staff of the famous Municipal School of Technology at Manchester, for example, includes a director of paper-making and bleaching at £525 a year, and professorships in photography and textile fabrics, at salaries of over £400 a year each. More strictly scientific posts on the same staff are remunerated with stipends ranging as high as £700, and the principal of the school receives £1000 a year. Indeed, with the exception of a few administrative heads, the best-paid officers in the educational service are usually to be found among the professors of the technical colleges.

A Last Word on the Service. Comparisons show that the Educational Committee for the capital is distinctly more stringent as to the qualifications of teachers than the majority of education authorities elsewhere. This is amply compensated, however, by its more liberal rates of pay, in which respect it is rivalled only by a few of the leading corporations.

With regard to the education service generally we may close as we began, reminding ourselves that to have a part in the training of the coming race of citizens is to share in a great and honourable national duty.

ERNEST A. CARR

The Diversity of the Forms of Life and their Classification. Where Animal Life branches off from Plant Life. Vertebrates.

THE LIVING WORLD SURVEYED

With our last chapter we completed our survey of the one-celled forms of life, noting that the existence of sex has lately been discovered even so low in the scale; and we noted also that the many-celled forms of life arise each by the manifold division and multiplication of a single cell, of which the offspring are not similar but different. With this central fact, upon which all else depends, we begin the study of the multicellular forms of life, among which we ourselves illustrate in a new sense the saying that the last shall be first.

The Law of Recapitulation. All the visible forms of life, of which we know so many, as well as hosts of those which can only be seen with a lens or lenses, are multicellular. Each arose as an individual from a single cell, and each thus illustrates a profound and mysterious law, which lies at the foundation of the principle of organic evolution—the law that living individuals *recapitulate* in their personal history the history of the race from which they are descended. This is the great "law of recapitulation," first recognised by Von Baer. We must accept it in a moderate form. All the stages in the history of the race are *not* to be found recapitulated in the history of an individual. Many stages are often omitted, or merged in one another, or slurred over. Nor can we entirely rely upon individual development as a key to the history of the race. But when these and other qualifications are recognised, Von Baer's law remains fundamental and illuminating. Of all its instances, none is so constant and complete as the fact that every multicellular individual arises from a single cell in its own brief history, while all multicellular organisms are assuredly evolved and historically descended from the one-celled and comparatively primitive forms of life. To this law we must later return.

Multicellular Organisms. But first we must take a more general view of the world of the multicellular organisms. Their *kinds*, and the differences between them, are numerous and profound—a whale, a mushroom, a bee, an oak, a man, all are multicellular organisms. There are many scores of thousands of kinds of beetles alone. The kinds of plants are countless. For "kind," let us use the scientific term *species*, and say that the earth, the air, the sea, and all fresh waters are filled with hundreds and thousands of species of multicellular living things, besides all the unicellular creatures which we have already considered, and many of which exist as parasites upon their superiors. The tremendous question arises, Where did all these species come from? This is the great and ancient problem of the "origin of species," which is only second, in our study of life, to the problem of the origin and nature of life itself. But we certainly cannot begin to study the question of species at all until we have properly surveyed, in outline, the kinds and the distribution of species. We must look at the living world as "naturalists," students of "natural history," and see what kind of picture it displays.

We find an unthinkable multitude of living beings, struggling for life with and against inorganic Nature and each other. Individuals soon die, but many leave offspring behind them, almost invariably by sexual reproduction, the essential fact of which we have already studied with some care. The offspring almost invariably resemble their parents with great closeness, so that elephants beget elephants and not roses, oysters, mice, or men, and so in all cases. This is the obvious fact of heredity, which the shouting ignorance of our day is sometimes heard to deny, and without which the world of life would immediately become unrecognisable.

Difficulty of Classifying Species. Our first task is clearly to try to sort out or classify this bewildering variety of species, and to find some order in this apparent chaos. This is the task of the *systematist*. The attempt to find system and order in the living world was begun, on a splendid scale, by the mighty Aristotle. It has been pursued by science ever since, and never with more zest than today.

There *is* order in the apparent chaos. While each species remains closely true to itself, with the rarest exceptions, *usually* of no consequence, we can yet see that some species are so nearly like others in certain respects that they must be thought of together. A duck and a sparrow are more alike than a duck and a fir. This is only one instance of what seems to be a system of *natural classification*. The mind of man loves and requires order—a fact which no philosophy can ever exhaust or ignore—and our passion for order is largely satisfied, though it is also often baulked and puzzled, by the living world. Just as an eagle and tomtit are so similar, though so different, that we call them both birds, so we call a fir and an oak trees, a minnow and a shark both fishes. We can go a long way in this direction, and savages today and the earliest thinkers will all agree with a modern student. But difficulties arise. We incline to call a whale a fish, or even to call a bat a bird, and an eel a snake. But a whale is really a mammal like ourselves, bringing forth its young alive, feeding them with its milk, and having warm blood even in the Polar seas. A bat is a mammal, too, and an eel is not a snake, but a fish. Clearly our science of systematics will require to look closely at apparent resemblances, and to judge more deeply than popular opinion. The instances here quoted are striking and

extreme, but for any one such there are many which are subtle, and which perhaps can scarcely be decided.

Transition Forms. Another type of difficulty is funished by creatures which seem to be of one kind at one period of their lives, and of another kind later. Some young creatures live in water, swim, breathe by gills, and can only be called fishes. Yet when they grow up they develop lungs and limbs, and breathe air as we do. Are we to call a tadpole a fish, and a frog a reptile, or what shall we do? Here is a case of a creature which recapitulates the history of its race in a most sensational way, and teaches us that species merge into one another. We have both to distinguish them and to relate them.

Yet again, when we have elegantly distinguished such vastly different creatures as birds and reptiles—the first flying free, the second crawling, the first with feathers and the hottest blood of living beings, the second with scales and cold blood, the first with wings and no teeth, the second with teeth and no wings—we dig among the rocks, and, behold! a fossil being of a kind nowhere now represented in the living world, which was neither reptile nor bird, but yet was both, a bird with teeth, a reptile with wings. We can only conclude that once there existed transition forms from reptile to bird, and that the lark is descended, or ascended, from the lizard—a discovery as startling as it is superb. But consider what a task is ours today when we try to arrange the living world in its species! The task was easy when no fossils were known, when the strange individual development of many creatures was unknown, and when it was supposed that Deity had made all the different kinds of plants and animals in the beginning as they are now. On the other hand, the study of species is far more worth while now than then. Then it could have no meaning; living forms were what they were by the caprice of Deity, and no further sense or reason was to be looked for. Now the transformation of the tadpole, the teeth of the primitive bird, and verily every minutest fact which the knife, the microscope, and the test-tube can discover about any species, either means something new or will certainly be found to have a meaning some day. Let us try to look at the chaos-cosmos of the living world in this way.

The "V" of Life. At least one immense fact is clear—that the living beings we know may be divided into two mighty "kingdoms," as the old naturalists called them—the "animal kingdom" and the "vegetable kingdom." Each comprises myriads of species, which range in size from the microscopic to the immensity of the fossil reptiles of North Africa, or of the great trees of the North American continent. Yet an amœba is more nearly related to a mammoth or whale than it is to a microscopic, one-celled green plant—at least in the fundamental chemistry of its life. The amœba, like its tremendous relative, is an animal, feeds and moves, and has its being like animals, while the apparently very similar alga is a plant, radically different in its mode of life. We have already studied this fact, and know that the difference between the animal and vegetable kingdoms is fundamental, and that all animal life depends upon vegetable life, which, in its turn, depends upon its power of dealing directly with sunlight.

If we must arrange these kingdoms in an historical or evolutionary order, as our later chapters will show to be necessary, we are struck by the fact that the simpler forms of each resemble each other more closely than the more complex forms. The amœba and the one-celled alga are much more alike than the whale and the oak. Interpreted by the light of the idea of organic evolution, this must mean that the two "kingdoms" have had a common origin, from which they have since diverged.

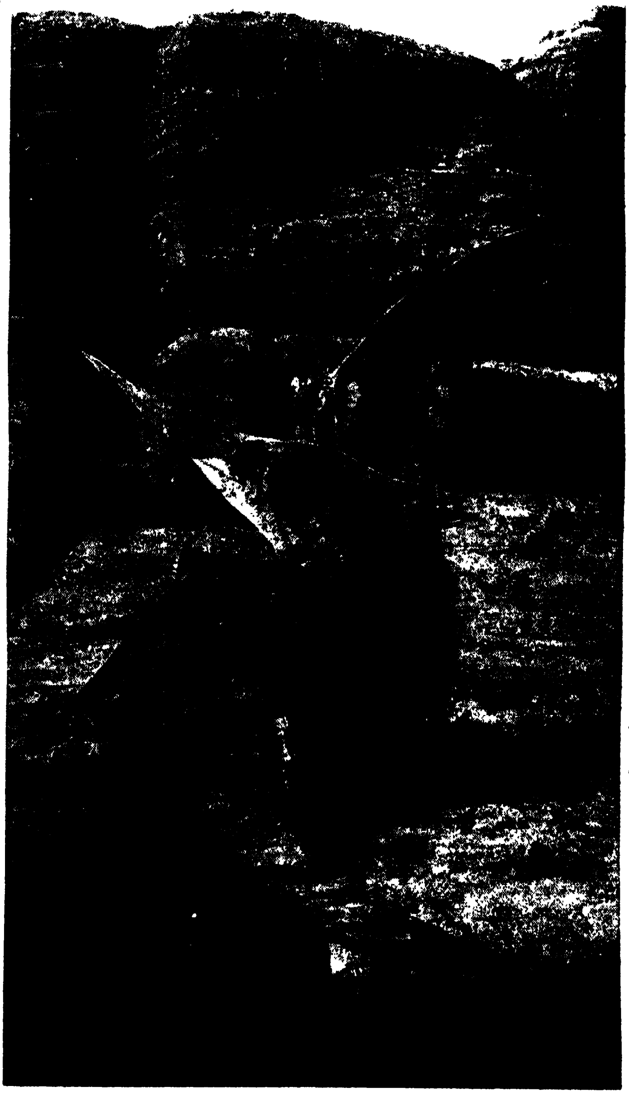
We might thus represent the whole of the living world as a V. At the extremity of one limb would be monkeys, apes, man; and the great flowering trees, oak and sequoia and so forth, would be at the extremity of the other. At the starting place of the V we should have no difficulty in finding forms of life which are both animal and vegetable, or neither. These creatures are a great puzzle in many ways, and need expert study, but their existence has this satisfaction for the mind: that they serve to indicate the kind of undifferentiated or unspecialised forms of life from which the definitely animal and definitely vegetable have arisen. We have already seen the case of the bacteria, which are called plants, and considered to furnish the humblest department of botany, but which, in their essential fact of nutrition, are *animal*, as are all the fungi. On other grounds we may decide to call the bacteria plants, but they show that living forms are a V, at the beginning of which the clear distinction between the animal and the vegetable cannot be drawn, because it has not yet come into existence.

The "Y" of Life. But this often-used comparison must be improved upon, because of our discovery that the whole of the animal world depends for its existence upon the vegetable world. Therefore, a more accurate comparison would be with the letter Y; and we must allow that the stem of the Y endowed itself with the gift of chlorophyll somehow, and that, *then*, the animal stem could start on its special and divergent path.

When we compare the animal and vegetable kingdoms, the first fact we observe is the deep similarity between them, after all. Both consist of individuals that must breathe and feed, that die and reproduce; both display the fact of sex; both consist most conspicuously of multicellular individuals, each of which developed from a single cell, itself the product of the fusion of two cells, derived from parents of opposite sexes; both exhibit adaptation to the circumstances of life—and the list of similarities might be indefinitely continued. Not to insist upon them before we proceed to differences would be to forget just what the study of life has triumphed in proving. The *identities*—more than similarities—between animals and plants are immeasurably more important than the differences.

In all its varieties, Life is One. Plants are not half-alive, nor alive in a manner of speaking, nor partial achievements along lines where animals have wholly achieved. Plants are as alive as we are, in all essentials of life; and Wordsworth was far nearer the truth, as modern biology is revealing it, when he said, "And I believe that every flower enjoys the air it breathes," than the nineteenth century supposed.

Therefore we must have and pursue one single study of life, which we call biology; and the science of animals, or zoology, and the science of plants, or botany, must be looked upon as branches or departments of biology. We must have deeper ways of recognising life than, for instance, by *movement*. We see an insect crawling over a leaf, and we call the insect alive, and think of the leaf as comparatively lifeless. But the truth is that (fortunately for insects and all other animals) the vital powers of the leaf take a different direction, which shows itself in movement to only a very slight (though definite) degree, but which is just as wonderful and every whit as vital. Also, let us avoid the popular error of using the term "animal" to mean only mammals. An amœba, a bird, a bee are animals, just as much as cattle or dogs are.



A GIANT PTERODACTYL
From a restoration in the grounds of the Hagenbeck Park, near Hamburg.

In order to correct our unconsidered ideas, we should have a kind of bird's-eye view of the two "kingdoms" in our minds, and should be always able to refer any living being we see to its place in the mighty System of Nature, as Linnæus called it. Thus, if we ascend along either limb of the Y of life, what forms shall we successively encounter? Merely to classify is not sufficient. We must know whether to place reptiles above such creatures as frogs, or below them; whether to place ferns above violets, or below them, and so on.

Determination of the Highest and Lowest Forms of Life. How are we to measure the height of any creature in the scale of life? The fossils and the history of life will help us, to some degree, because in general the highest forms of life are the most recent. But that is not a constant rule, for unfortunately evolution does not necessarily mean progress, though there is no commoner delusion in popular biological ideas. There has been, and always is, retrogression, degeneration, as well as progress. Nor can we judge by size. A man is higher—nay, a rat is higher—in the scale of life than an extinct reptile that measured a hundred feet long.

We shall meet with more success if we judge by *complexity of structure*, though that is not all, or enough, as we shall see. But it is much. We have already learnt that the vast advance from the unicellular to the multicellular forms of life consists in the fact that the latter are not merely many-celled but *different*-celled. The number would be perfectly futile were it not for the difference. A man is not superior to a toadstool or a gibbon because he has more cells in his body, but because he has more kinds of cells in his body; and when we conclude, as we shall, by noting what kinds of cells a man has more of, we shall have discovered the whole of the truth.

The fact that a living being has different kinds of cells in its body means that its vital powers become far more varied and efficient and admirable. Any biologist would unhesitatingly

mark a bee far above an oak, for instance, even though the oak is so large and glorious, because the bee really has vastly more complexity of structure, more kinds of cells, in its little body than the oak in its big one. The immensity of the oak depends upon *repetition of parts*, and the wonder of the bee upon *differentiation of parts*. The oak has many leaves, for instance, but they are all similar, and many woody fibres in it, but they are all made of similar wood-forming cells.

Tests by Complexity and Differentiation of Structure. Judging by complexity and differentiation, therefore, and not by mere number as such, let us note how, in the agreement of all biologists, the map of the living world may be outlined. First, for the vegetable kingdom, which can claim superior antiquity, we find, after the long inquiry which our predecessors have made, that two great classes may be recognised. There are plants which bear flowers, and those which do not. All which bear flowers are more closely related to each other than any of them can be to plants which have no flowers. The violet and the oak belong equally to the superior and later class—size has nothing to do with it. The reader may possibly be surprised to think of the oak as a flowering plant, but so it is, and so are all the other great trees, with many of which we are so familiar. Many may have very inconspicuous flowers, but all bear true flowers, no less than the rose, or than such a member of their own group as the horse-chestnut.

Botanists have learnt that the flowers are the reproductive organs of the plants which possess them. But other plants have reproductive organs which, instead of being apparent, are hidden. Therefore the flowering plants are called *phanerogams*—literally, visible marriage; and the others *cryptogams*—literally, hidden marriage. Among the cryptogams, travelling upward, we meet the algæ and fungi, which we have already studied to some extent, and then the mosses, and then the ferns. A whole vast age in the history of our globe, the age from which we now gather coal and all its consequences, corresponds to the dominance of giant ferns in the vegetable kingdom; and students of the history of botany search for and find with deep interest the earliest evidence of the first flowering plant or phanerogam. Even greater and greater complexity of structure—which means *always*, at bottom, greater variety of cells—is the feature of vegetable life as it ascends; and on this profound ground we must reckon "the meanest flower that blows" above the tallest and most luxuriant fern that ever was or will be.

Now consider the animal kingdom, and let us try to arrange the order of the different forms of its life in ascending series, using the same criterion, complexity of cell structure, as in the last case. Just as there we found a natural classification into two groups, *with or without flowers*, so here we find a natural classification into two groups, *with or without backbones*. A backbone or spine or spinal column—all these names are synonymous—consists of a large number of relatively small bones, piled in a column upon one another. These bones are called vertebræ. Hence the backboned animals are technically termed *vertebrates*, and the backboneless are termed *invertebrates*.

Vertebrates—the Higher Animals. Generally, and on the whole, with one tremendous exception of profound significance, as has been pointed out by Professor Bergson, in whose classroom in Paris these words are written, the vertebrates are the higher animals. They are certainly the higher in that they include man, the highest form of life hitherto. They are certainly evolved from the invertebrates, as the phanerogams are evolved from the cryptogams; and, as in that case, they are certainly more recent in time as a whole. Only we must now and henceforth beware of the disastrous error into which the theory of evolution has fallen until lately—the idea that evolution is *linear*, and proceeds in successive stages along one line or not at all. Life is not thus limited. The Y of life is really a tree.

The invertebrates may give rise to vertebrates, and thence even to man, but this does not mean that the invertebrates cannot develop along other directions, without the evolution of a backbone at all, or that those other developments may not be great and wonderful. In fact, this has happened; and he would be a very shallow and thoughtless biologist who ranked a cod above a bee or an ant because the cod has a backbone and they have none. Even in respect of time, in the light of the new idea that evolution is not confined to one line, we realise that the social insects may be much more recent products of the evolutionary process than not merely any fish, but quite possibly any mammal, including even man himself.

The Route of Evolution. It is beyond question to Professor Bergson that we owe the idea and the proof that the evolution of life may proceed and does proceed along not one line but many, and that each of these lines must be studied impartially, and not merely the line which has led to us, if we are to realise the whole range of vital possibilities, *and even if we are fully to understand ourselves*. Life may even attain similar results, for its own good reasons, along utterly dissimilar lines. The eye of the invertebrate scallop is very similar to our own, though they lie along utterly different evolutionary lines; and the insects have achieved wonderful and admirable societies, for vital ends, no less and often much more than man himself, though we should have to go back almost to the beginnings of Life in order to reach the point whence diverged the lines that have led respectively to the bee and to man.

Ascent in the Animal Kingdom. With these principles grasped and remembered, we may venture to arrange the animal kingdom in an order which is, *on the whole*, an order of time and of ascent in the evolutionary scale. Like the vegetable kingdom, this begins in forms of life which are neither animal nor vegetable, but yet are both. The simplest typical and representative animal is, of course, the now familiar amœba. Above it and its unicellular fellows—many of such tragic and horrible importance to

ourselves—come a vast multitude and apparent chaos of multicellular but invertebrate animals. Low in the scale are such creatures as sponges and star-fishes. Then there are the worms; and we may be sure that the insects have evolved from the worms, because (among other reasons) we find a worm-stage, as it were, in the history of individual insects, as we found a fish-stage in the history of individual frogs; the caterpillar becomes the butterfly. But it is impossible to arrange the invertebrates in a logical and continuous series, as we practically can arrange the vertebrates.

This is not our fault, though students have long tried to remedy it. The reason lies in the nature of the facts. The various kinds of invertebrates have not evolved from one another along a single line. They are evolving along many lines; and only if we had what we can never have, a complete museum of all the invertebrate forms that *have* existed but are now extinct, could we really arrange the invertebrates in their natural relations. Here, therefore, no more will be said about them, save to insist that certain kinds of insects, already named, represent the highest achievement of invertebrate life hitherto, and that no man can say how far life may not ascend in that direction. The supreme mark of these insects is the development in them of the miracle called instinct; and one of the greatest services of Bergson to modern thought is his recognition of the importance of this vital development for the understanding of the minds and the behaviour not merely of insects but also of Life as a whole.

INVERTEBRATE AND VERTEBRATE SKELETONS

The sections above of an animal with a shell and an animal with a backbone show how in the one case the supporting structure is outside the softer parts, and in the other case inside.

The Origin of Vertebrates. But, whatever Life may yet be going to do along invertebrate lines, certainly great things have been done along the line of vertebrates. Our first question is as to the origin of these vertebrates. From which of the known kinds of backboneless animals did the backboned forms emerge? This is a question which we should be able to answer, but we cannot. A distinguished physiologist, Dr. Gaskell, has argued that the type represented by the king crab offers the origin of vertebrates. Few agree with him, but other suggestions are perhaps equally open to criticism. The origin of vertebrates thus remains one of the unsolved problems of biology, and it would be useless for us to attempt to discuss it here. All we need know is that the period must have been very remote, and that apparently a complete backbone did not come into existence all at once, for we find beings which have only a backbone at the head end of the body, as if the rest of it had not yet developed.

We have insisted upon the backbone, made of vertebræ, as the feature of the vertebrates. But the case might be put more generally. Compare a lobster and a fish. The differences in structure are numerous and immense. But by far the most striking is that the skeleton of the lobster is outside its body, while that of the fish is inside its body. The invertebrates, if they have a skeleton at all, have an *exo-skeleton*, as it is called, *exo* being Greek for without, but all vertebrates have an *endo-skeleton*, *endo* being Greek for within. The shell or case or hard covering of an invertebrate is not bone, nor anything like bone except in its hardness. Vertebrates have a *bony* endo-skeleton, of which the most characteristic part is the backbone.

But there is an exception to this, for sometimes we find gristle or *cartilage* instead of bone. There are many cartilaginous fishes which have no true bone at all. But fishes are the lowest and earliest vertebrates; and our own bones, in most cases, are developed, in our individual history, from cartilage. We may therefore, applying Von Baer's law, conclude that the bony skeleton of vertebrates was first of all cartilaginous. We also note that there is no evolutionary continuity from the hard covering of any invertebrate to the cartilaginous or bony skeletons of vertebrate. The vertebrate skeleton was something entirely new in the evolution of living forms.

Orders of the Vertebrates. Finally, a paragraph will suffice to state the sequence and names of the chief divisions of vertebrates. These divisions are technically called *orders*. First, oldest, lowest, simplest, are the *fishes*. Next are the *amphibians*, such as the frog, which are, as it were, fishes in youth, and when adult become practically members of the next order, which is the order of *reptiles*. We have already incidentally learnt that the reptiles are the evolutionary parents, *somehow*, of the order of *birds*. Also, from the reptiles, or else from the amphibia, there arose the order of *mammals;* and the Mammalian Order comprises a long succession and divergence of families, culminating at present in the "paragon of animals," as Shakespeare called him, whom we know as the *Genus homo* or man. C. W. SALEEBY

Letter Copiers. Calculating and Bookkeeping Machines. Cash Registers. Duplicators. Dictation and Time Recorders.

OFFICE LABOUR-SAVING DEVICES

The stress of modern competition and the small margin of profit that it allows make it important that every business organisation should effect all possible economies in time and money. For this purpose many ingenious labour-saving devices and systems have been placed on the market. The number of these is exceedingly large; and in this chapter we review some of those that have proved themselves of general utility.

Letter Copiers. There are several self-pressing copy books which are light, handy, and very compact, costing only 3s. 6d. to 5s. 6d. each, according to size, while the refill books can be obtained from 1s. 3d. to 2s. 3d. This device is useful to those with a small amount of correspondence, or to travellers and business men on their holidays. The letters are placed under damped pages in the ordinary way, and the book in then rolled up either on the table or in the hands, the result being a good copy of either a single letter or a number of letters. The Zimer Self-Copying Book appears to be one of the cheapest of the portable copying presses.

There are also several roller press copiers, the newest being fitted with an automatic cutting attachment, enabling from thirty to forty letters to be copied in a minute. The machine works by turning a handle, which brings the letter and the copying paper together and then cuts off the copy at the right position without any help from the operator. It is fool-proof against any premature use of the cutting-knife. There are two types of machines: one uses some kind of water bath which wets the copying paper, the other uses no water, but has a paper specially prepared to take clear copies without being wetted.

The Roneo Letter Copier. Costing from twelve guineas, this is one of the best machines that do not use a water bath. It can be worked either by a handle or by turning on an electric switch. There is no drying drum, and if the original letters are fed askew into the copier, the machine automatically straightens them so that the originals are not creased or blurred. As many as twenty copies can be taken from one original, either hand-written or typewritten. The Shannon Letter Copier is a good example of the wet paper machine. It costs £13 and upwards, with the rapid cutting attachment.

It should be remembered that all letter copiers pay for themselves in a short time by saving the cost of expensive letter books and screw presses or carbon paper. The copies, moreover, are valid in a court of law.

Mechanical Carriers. Wires, ball or gravity railways, pneumatic tubes and electric carriers, are used. The simplest and cheapest is the wire carrier. Worked by propulsion by pulling a handle, the carrier runs up steep inclines, round corners, and over bridges between various departments. The wires are supported by stations either in the ceiling or in the floor, and the latest mechanism is instantly adjusted to high or low speed. The car is usually designed to carry cash and bills to and from the sales counter and the cash desk, but attachments are supplied for conveying papers and pass books. The horizontal wire message-carrier is also adapted for transmission of paper bundles half an inch in thickness in counting-houses, order and despatch departments of wholesale and retail establishments, and in banks, insurance offices and factories. In the new types there is no complicated mechanism, and the operation is simple and certain.

The cash and document lift is also simple and cheap. It connects different storeys, and is a speedy means for conveying cash, documents, and orders, messages and small packages from floor to floor. It is worked by pulling a handle. The ball or gravity cash railway was introduced in the early 'eighties, and is still largely used.

A Pneumatic Tube Device. The pneumatic despatch tube is the most practical means of intercommunication over an entire building. One of the simplest systems is the Lamson Foot Power Service, designed for use in comparatively small retail businesses where a power-operated plant would be out of the question, or where structural conditions are against the working of other systems. It consists of a cabinet with an air compressor and a lever that is worked by a movement of the foot. The cabinet may be fitted with half a dozen tubes, if necessary, for communicating with stations in six different parts of the establishment. Small manufactured parts can be sent for finishing or assembling from place to place in factories, and the work of hotels and clubs, warehouses, stores, and offices generally is quickened and cheapened.

The power-operated pneumatic tube soon pays for its rent or purchase in large establishments. Continuous service and consecutive delivery of carriers make the tube of greater value than even the telephone and telegraph in the actual handling of business. There are various ways of working the tubes, by air pressure, or suction, or a combination of both, and by a continuous current or an intermittent current.

There is also a pick-up and delivery carrier which automatically picks up papers from a despatching shelf and delivers them on to a receiving shelf in another part of the building, and then picks up and carries to its destination any documents on the neighbouring shelf. It can be used for working a central or distributing station, with a line of shelves for despatching to a number of single stations. The articles have only to be placed on the right shelves, the carrier

does the rest. The system is operated by a belting attachment to a small motor.

In the cable system there is an endless ever-running cable track that whirls to their destination every kind of small article. The working cost is extremely small; a tiny half-power electric motor will operate, at high speed, ten or more assistants' stations. The motor can be started or stopped just as easily as an electric light can be turned on and off. Every box unerringly delivers at its proper station, travelling at a speed of 600 to 900 ft. in a minute—round corners, upstairs, downstairs, through walls and floors. The cash desk can be placed in any part of the building, so that valuable selling and display space, which would otherwise be given up to the cashier, can be utilised.

The cost of each of these mechanical carriers depends on the length of the line and other conditions of service. An estimate and scheme can be obtained without any charge from a good firm, such as the inventors of the pneumatic cash carrier, the Lamson Store Service Co., Ltd. The systems when installed can either be leased or bought outright.

Automatic Numbering and Dating Machines. These are used for numbering documents, orders, packages, records, tickets, and card indexes. They have various movements which are governed by the position of the pointer on the dial in front. The machine with three movements will print either consecutive numbers or duplicate impressions, or it will repeat. Some machines of the latest type have seven movements. Every time the machine is used the number advances to the next highest. Both the change of number and the inking are automatic. The figures are of steel, and they work with rapidity and absolute accuracy. A good machine costs about 42s. and upwards. There has also been introduced a self-inking dating machine with steel figure wheels for cancelling Insurance stamps in establishments where a large number of insurable employees are engaged. The price is 14s. 6d.

Cheque Protectors. These are employed to prevent any forger from increasing the amount for which a cheque is made out. The Cheque Protectograph cuts the figures indelibly into the paper, so that erasure or alteration is impossible. A dial controls all the operations of the protectograph. The price is £7 7s. The Chicago cheque perforator works by single figures. The handle is turned to the desired character on the dial and then pushed down so as to ensure a full stroke. The operation is repeated on each character until all the figures are perforated into the cheque, which is then removed by pressing a lever. The price is 50s.

Calculating Machines. These are of very various kinds and uses. One of the simplest is the printer-adder or lister, which prints the figures as well as adds or subtracts them. It is worked from a keyboard like a typewriter, and is small, compact, and light. It is very useful in making out monthly statements of accounts from the ledger for customers. The operator transfers the dates and amounts from the ledger as fast as he can read them. When the account is completely transcribed the total key is pressed, and the machine automatically adds up all the figures, and prints the total at the end of the statement. Thus the pencilled total in the ledger can be checked, as the monthly statement is incapable of being wrongly added up. As many as 800 statements can be turned out in a day by a single machine.

No expert bookkeeper is needed for the work. It is a mere matter of copying. The hidden wheels of the machine do all the figuring. If two or more copies of each statement are required, for travellers or office record, carbon copies can be made on the machine as on a typewriter. The work of taking out a trial balance can be done in half the usual time, and with an electrically operated listing machine the task is still more rapidly performed. A repeat key obviates the need for typing out items of similar amounts, and in the printing the dates and the figures are distinguished by different coloured inks. From £25 to £180 is the price of a Burroughs adding machine, which is one of the best known of the printer-adders.

Multiplication and division can be done on an adder or listing machine; but these operations are more easily carried out on another kind of keyboard machine, which does not print as well as calculate. The simple adding machine is not so useful in making out monthly statements as is a printer-adder, and in banks, where a list of items added has to be made out either by hand or by machine, it is not so serviceable as its rival. But in most other mercantile, manufacturing, insurance, and railway calculations the simple adding machine seems to be the speediest mechanism. It multiplies five to seven times as fast as with a pencil, and divides four to five times as quickly. In addition it is claimed to be twice as rapid. A simple key stroke does all the work. Mistakes used to occur through a key not being sufficiently depressed sometimes to move the calculating wheels, but in the latest machine a locking device comes into action if a key is not properly struck, and the instrument refuses to work until the error has been rectified. In the departments of bookkeeping, pay-roll, cost-keeping, billing, and accounting this machine is a great time-saver with absolute accuracy. One of the best models is the Comptometer of the Felt & Tarrant Manufacturing Company. It costs from about £50.

For the intricate calculations of actuaries and other computers a machine known as an arithometer is largely used. Working by means of slides and markers, it is not so rapid as a keyboard adder, but in difficult figuring it is a time saver of high importance. It is used in Government offices, insurance companies, and by principal computers everywhere. The special claim made for the Layton Improved Arithometer is its reliability. It is designed to withstand the hardest wear, and it shows in plain figures all the operations performed, so that the human element is reduced to a minimum. The new model has an electric drive. The machine costs from 25 guineas.

Bookkeeping Machines. These are a combination of typewriters and keyboard calculating machines. They write in books, loose sheets, or cards of any size with equal facility. The invoicing-adding machine enters into day-book, and at the same time charges to customer and makes out the invoice. Carbons are inserted where duplicate invoices are required. Simultaneously with making out the invoice and day-book entry, the machine automatically adds the item with mechanical precision. The totals are automatically entered on a moving proof-sheet, which provides a daily record of all entries made. Compared with the old way of making entries by hand, the machine saves one writing and one checking, because invoice and charge must agree, and both items must be correctly totalled because they are machine-added at the same time.

The bookkeeping machine posts to ledger and simultaneously makes out the statement, adds the totals and furnishes facsimile evidence of all work done. The old way of bookkeeping was first to write the entry, then to add the figures, and afterwards to check for mistakes. The machine reduces these three tasks to the single operation of making the entry. The single operation of typing the entries posts to ledger, makes out the statement, automatically adds the figures, lists the totals—both debit and credit—and proves the work correct; for the total of ledger entries must agree with the total charges in the day-book, journal, or other posting medium. If the bookkeeper has made a mistake the machine automatically shows it up on the proof-sheet, and the error is at once found on the day it is made.

The wearisome labour of taking a trial balance is done away with. Taking a balance is reduced to the simple operation of assembling and listing the ledger entries, which are ready to be taken off at the end or any part of the month. The best machines write on a wide, flat surface, all writing plainly in sight and instantly available; there is perfect tabulation in all columns—every page as clear as a line of type. The Elliot-Fisher Company's machine enters to ledger at the rate of 180 to 200 postings an hour, and effects economies which soon pay for its first cost.

Some firms use a carbon in writing invoices and making day-book entries, and so perform these double operations at the same time. This can be done by the Loose-Leaf Day-board, by pen and ink writing in the ordinary way.

Typewriting Devices. The Wahl-Remington typewriter calculates as well as types. A small but excellent adder is fastened to the front of the machine and connected with the figure keys, and it gives on a front dial the total of all lists of figures that have been typed. At a touch on a lever the machine subtracts instead of adds. If the operator should attempt incorrectly to type the total given on the dial, the machine locks, and will not work, and the dial shows the exact amount of the mistake. It is a typewriter with a brain.

The Hammond Multiplex typewriter has an instant change of type or language that is brought about simply by turning a button. The action of the Multiplex is under automatic control, giving a uniform impression entirely independent of the operator's touch, thus doing away with all the trouble of learning typewriting. The reversible carriage enables the operator to write in either direction for such languages as Hebrew, Persian, and Arabic. A mathematical model is also made, enabling engineers, professors and others to write in either higher or lower mathematics. The cost of the small model Multiplex is £21 9s. 6d., and that of the mathematical model is £24 9s. 6d.

Among the small labour-saving devices for typewriting are paper and book holders that keep the operator's notebook or other copy in such a position that there is no necessity to stoop, and all strain on the neck and back is relieved. The Balaban holder is one of the best, and its cost is 7s. 6d. and 10s. 6d. Typewriter desks are another useful invention. They have the appearance of ordinary writing tables or desks, but on lifting a flap or raising the top there is brought into position the platform upon which the typewriter rests at a convenient height for typing. At the back of some of these disappearing typewriter tables is a large stationery rack, which always remains in an upright position during the closing of the table. The tables cost from £5 15s.; the desks are rather dearer.

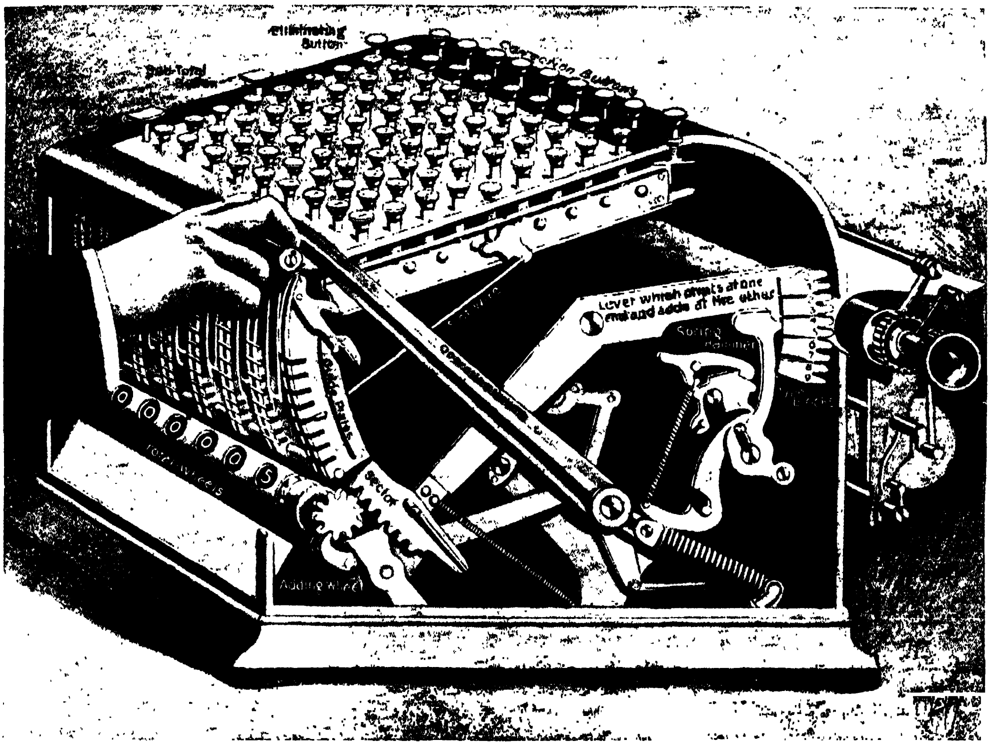
A little time saver in typewriting is to have the full stop on the shift key as well as on the ordinary key. The use of two-coloured ribbons can often be avoided and more work can be got out of the ribbon by using a red carbon when a red impression is required. In typewriting postcards these should be obtained in strips to prevent the separate card from shifting in the machine. They cost about 8s. 6d. a 1000 when printed with the name and address.

Registering Tills. These are made in great variety, adapted to every kind of selling business. In one of the simple kinds, a lever has to be set to mark the amount of the sale; then, on turning a handle, a bell rings to announce the transaction, a public indication of the amount appears, the cash drawer opens, the item is printed on detail slip, and a receipt is printed for the customer with the date, the initials of the assistant, the proprietor's business card. An autographic attachment enables written details of the sale to be made opposite printed amounts. In the better class of machine there is an adding mechanism, and a keyboard by which the transactions are more rapidly registered than by lever setting. For large and very busy shops an electric motor is employed to drive the registering machinery without any turning of a handle.

In the highest type of registering till the proprietor is able to see at a glance the totals of his cash sales, credit sales, money received on account and money paid out. Separate cash drawers for each assistant are provided, and the total sales of each are recorded, together with the grand totals for the whole business. These registering tills prevent disputes with customers, and give them a printed receipt dated and initialled. They help the assistants in their work, and

protect them from suspicion, show which of them is selling most goods, and record the number of the sales by each and the total cash each of them took. When the registering till is combined with the sales slip system, the machine prints the amount of the sale on the slip, and thus checks the figures written by the assistant.

The register also prevents mistakes in paying out transactions. Before the cash drawer can be opened the record must be made on the register. By the same operation, the amount is printed on a paying out check which is signed by the person to whom the money is paid, and then filed for reference. All money paid out is totalled on a



PICTORIAL DIAGRAM SHOWING THE MECHANISM OF THE BURROUGHS CALCULATING MACHINE

This simplified diagram shows the action of one of the levers, of which there is one for each column the machine can add. The depression of the key, marked 5 in the drawing, moves a wire into a slot, and allows the sector to drop five points. The opposite end of the lever is thus raised five points, bringing a type figure 5 opposite a spring hammer. The pressing down of the operating handle strikes and prints the type on the paper. As the handle returns to position, the rack on the sector engages with the cogs on the adding wheel, and the number 5 is added to the total already attained. The total can be printed by pressing a special key and pressing down the operating handle.

separate adding counter, and a special counter tells how many times money has been paid out. The National Cash Register Co. are the largest makers of these machines for the smallest and the largest retailers in every trade. Their adding registers cost £8 and upwards. Messrs. Gledhill and Sons, of Halifax, have produced a total-adding, voucher-issuing register that is admirable in cash checking. Its price is £22 10s. without the numerator.

The National Office Register. This is an adaptation of the machine of the National Cash Register Company to the transactions of general business offices. The entering, registering, counting and classifying of orders, collections, cash transactions, disbursements, and distributions are now computed on an instrument with adding wheels and printing mechanism. By the new system of checking, which does not disturb existing methods of bookkeeping, it is easy for the principal of any business to see for himself, in perfect secrecy, the figures which give him a complete statement of his affairs every night or any hour of the day. Incoming remittances are recorded instantly on the register, and at the foot of each letter is printed automatically a record of the registered amount and a consecutive number of the transaction. The total for the bank paying-in book is then found on the machine, saving the bookkeeper the worry of checking, and the machine prints this total on the paying-in slip.

The items of customers' bills are recorded on the register, which automatically adds them up and prints the total on the bills. All petty cash transactions are registered, because the cash drawer cannot be opened until this is done ; and a signed receipt is obtained and filed by the bookkeeper. In drawing cheques, each amount is registered, and the machine prints the amount on the cheque while recording it. In short, a permanent record is made of every transaction, and all details and totals can at once be verified. Each man in the bookkeeping department is

able to obtain a check on his work every day, and the time taken in registering is more than balanced by the time saved in verifying additions, calling over postings and the like.

The system is said by its inventors almost to cut in half the work of book-keeping. It is useful in manufacturing and wholesale houses, newspaper offices, insurance companies, auctioneers and estate agents, shipping agents, export firms, commission merchants, hire-purchase traders, and in fact for all engaged in monetary or mercantile transactions. Each machine is designed for the business that requires it, and the price naturally varies in accordance with the requirements.

Writing Telephones. Writing as well as speaking can now be done on the same telephone wire. A new instrument—the telewriter—will transmit in writing anything that is capable of being written or drawn with a pencil. Orders, messages, and sketches can instantly be sent and received in a manner that admits of no mistake or dispute. The telewriter is attached to the ordinary telephone wire, without any interference with the speaking service. When you want to talk, you talk. But if your correspondent is absent, or if you have a message requiring great accuracy in transmission, you press a button, and write on the transmitting pad, and your writing is silently reproduced on the receiving pad of your correspondent, even if he is away. You have a record of your message, and he has also a written copy in your handwriting. So there is no matter for disputes or actions at law.

Where numbers and prices are constantly involved, it is better to do business over the telewriter than over the telephone. It is quicker in the long run, and much safer. The most complicated orders can be sent from warehouse to factory, with figures, sketches, and explanations of a technical kind. As a double record is made, one for the sender and one for the receiver, no message can be overlooked or forgotten. Instructions or prices can be instantaneously transmitted from a central point to a number of subsidiary departments.

The sales department can be connected with the central counting-house for the verification of customers' credits; callers can be silently announced without interrupting the principal in the midst of important business; telegrams and cables can be sent and received from the General Post Office and from the Cable Companies at a great saving of time; and in London subscribers to the writing telephone can be directly connected with each other through a Telewriter Exchange.

For Stock Exchange business the new instrument is invaluable. The National Telewriter Company, of 20, Bucklersbury, London, E.C., rents the instruments, with transmitter and receiver, for £10 a year. The annual charge for two private wire installations, not more than three miles apart, is £22, and £1 for each further mile or part of a mile, exclusive of line rental and electric current. The purchase price of a set of exterior service instruments for private wire installation is £48; for interior service instruments, £42, not including wiring and fixing.

Telephone Devices. The telephone holder is a useful addition to either roll-top or flat-top desks. It allows the instrument to be extended for two feet or more, and the desk can be opened or closed without moving it. A good article costs about 14s. The extending arm, fitting in a socket fastened to a desk or table, is sometimes still more convenient. It pulls out with a single touch, and costs, complete with brackets, from 17s. 6d. to 25s., according to length. The Globe-Wernicke Company makes both these kinds of telephone aids. Paper blocks for writing down telephone messages are coming into general use; they are useful as reminders, but have, of course, no value as legal records. The telewriter, described above, serves this purpose much more effectively.

Duplicating Machines. Duplicates are usually made by one of three methods—the composition or parchment apparatus, the stencil instrument, or the type-setting machine. The best modern composition copiers are cheap, clean, and good for fifty or a hundred copies. The composition does not need remelting after every operation, as the ink either sinks to the bottom, evaporates, or dries, so in a few minutes the surface is ready to be used again. The stencil machines, however, are more largely used, as they give more duplicates. In the flat instrument the circular is typed or hand-written on a stencilling sheet, and this is placed in a frame, and sheets of paper are inserted beneath it, and inked by means of a roller passing over the stencil. The rotary machines are automatic in action, and therefore quicker and better in working.

The stencil is hand-written or prepared on an ordinary typewriter and placed on a roller. Then as fast as the sheets are fed into the machine the duplicates are produced. Motive power is supplied either by turning a handle or by an electric drive. The various rotary machines differ from each other in the inking devices, speed of working, automatic feed, and so on. The quality of the inks and the stencils also vary.

The D. Gestetner self-feeding rotary cyclostyle duplicator costs 16 guineas, and produces 60 to 80 copies a minute. The Rapax automatic duplicator of The Shannon, Limited, turns out 2000 to 3000 copies in an hour, and costs complete, with cover, £30. The Roneo self-feeding duplicator will produce from one hand or type written original up to 5000 copies, and costs 19 guineas, or 12 guineas without the self-feeding attachment.

The type-setting machines are of two kinds, flat and rotary. The Shannontype, a flat machine, costs £25 complete, with over 4000 types and indexed type-setter. It is worked by drawing a roller backward and forward, a copy being produced every time the roller passes over the type bars; the printing is done through a ribbon, as in a typewriter. The operation of setting up the type is simple, and can be learnt by any junior clerk in a few hours. An addressing device enables the address to be included in the text of the letter, and as the whole is printed in

one operation no contrast appears between address and text.

The Gammeter Multigraph is a rotary machine that costs 60 guineas, and duplicates at the rate of 4000 to 7000 copies an hour. It occupies only the space of an ordinary typist's table, needs but a junior operator, and can be learnt in an hour, as it is an automatic type setting and distributing machine. The separate letters of the type are arranged in grooves on a half cylinder of metal, all the A's being on one line, the B's on another, and so on. Another grooved semi-cylindrical drum fits into the machine alongside the other, and on this the type for the circular required is set up. By moving a pointer that runs up and down on a key alphabet, the grooves containing the letters required are in turn brought opposite the groove on the empty drum where a line of the circular is being set up, and the touch of a lever drives the letter from the one drum on to the other. With a little practice a short circular can be set up in a few minutes. A wide ribbon is then stretched round the cylinder on which the circular is set up, and the handle is then turned while the paper is fed into the machine, every revolution of the cylinder printing one copy.

An automatic feed, raising the output to 7000 an hour, can be supplied; but a practised operator, by hand feeding, can turn out 5000 an hour. Every copy is a typewritten letter, being printed exactly as on the typewriter from type through an inked ribbon. Besides duplicating, it prints office matter and general stationery at a saving of from 25 to 75 per cent. Every printed thing any office calls for—illustrations, and even half-tone engravings, and all kinds of advertising matter—can be well done on the little machine. It makes printing a simple and inexpensive affair.

The Roneotype is a rotary machine that produces letters at a cost of 2d. a thousand, and prints office stationery as well. Its flexible forms may be filed for future use, and one operator may print while another is setting or distributing type.

Addressing Machines. The Addressograph prints 2000 different addresses in an hour, at a cost of 2d. a thousand. Errors and omissions are mechanically impossible; the work is almost equal to typewriting, and a boy or girl with no previous experience can operate the machine. It is a perfect card index as well as an addressing machine, and having no intricate parts to get out of order, it will last for many years. For writing names and addresses on envelopes, dividend warrants and bills, and similar forms, it is very useful.

It consists of printing plates, which can be furnished ready for use, or stamped out as required by a special machine; a drawer of plates is placed in the magazine of the machine which is worked by a foot lever. It inks and brings each address plate forward, prints from it and automatically passes the plate into the drawer, and brings the next into position. Both of the operator's hands are free to feed in the matter to be addressed. One inking of the pads is sufficient to print 10,000 addresses. The machine can be fitted with duplicating and repeating attachments, enabling each address to be printed twice, or any number of times. A dating device can also be fitted for use in statements of account. Wages sheets with numbers, occupations, and rates of wages can be printed with automatic feed at the speed of 34 items in 30 seconds.

The Graphotype for embossing plates by hand costs £30; the more rapid electric motor-driven embosser costs from £70. The Addressograph itself costs £21, and addressed plates for it are supplied at 1½d. to 2d. each. The price of the electric motor and attachment is 12 guineas.

The Roneo Addressing Machine prints at the speed of from 1500 to 2000 different impressions an hour. The printing is from a typewriter ribbon, and the machine is about the size of a typewriter. The price is from 12 guineas. The Roneo Embosser turns out 400 to 500 plates a day by hand, and makes corrections and flattens out and uses again old plates. The price of the office embosser is 30 guineas, and the dating attachment 30s. The quick electric commercial addresser costs £42.

The Elliott Addressing Machine, it is claimed, also prints 2000 names and addresses in an hour. It prints from stencil cards, which, like the embossed plates of other machines, can be used as a card index. Messrs. Mackenzie, Schiff, Ltd., have a Rapid Addressing Machine, working with typewritten paper stencils prepared by any typist on an ordinary typewriter. It is guaranteed that each stencil—costing 30s. a 1000—is good for 10,000 impressions.

Time Recorders. Designed at first merely to enforce punctuality among employees, the registering and printing clock has developed into the chief instrument of an important time-checking and job-costing system. Each workman has a weekly time card, which he clocks whenever he enters or leaves the factory. The cost clerk, foreman or workman also clocks the various job cards that indicate the times when the jobs were begun, changed over, and finished. At the end of the week the job cards are summarised, and the totals entered on the back of the weekly time card to prove that all time paid for has been accounted to jobs.

By extending the system, the job card also shows the production cost, the selling price, and the profit or loss. The cards are kept ready for use in racks by the side of the clock, affording the maximum of detailed information with the minimum of clerical labour and stationery. The Gledhill-Brook Time Recorders, Ltd., supply their "Clipper" for £27 10s.

Among other types of timing registers for work-people are radial recorders, where the employee punches in the hole opposite his number, his action printing the time on a numbered chart or time sheet. In the key recorder, the employee takes a numbered key from the board, inserts it in the recorder and gives a quarter turn, which automatically prints the time and number on a travelling paper tape. The prices run from about £10 to £20 for some of these excellent

machines; but Time Limited have a Sign-it Time Recorder that costs £7 17s., and is guaranteed for five years.

Dictating Machines. These are an adaptation of the principle of the talking machine, for doing away with shorthand in the correspondence of an office. The whole of the typist's time is used in productive work, instead of a large portion being wasted in taking notes and waiting to take them. The dictating machines are reckoned to save 50 per cent. of the time, trouble and cost of conducting correspondence. The principal dictates his letters to the machine in privacy, while he is reading his mail. So he does not have to go through it twice; being alone, he can concentrate his thoughts better, and he can talk into the machine without any speed limit. Moreover, he has not to draw the typist away from her work for the purpose of taking down his notes. By touching a lever the dictator can hear at once what he had said and pick up the thread of his thoughts or make a correction either by oral message on the machine or by a note on the correction pad. The typist can start transcribing as soon as the first letter is dictated, leaving the principal to go on dictating.

The machine consists of three parts—a dictating instrument, a reproducing instrument, and wax cylinders for recording the dictated matter. If required, the combined dictating and reproducing machines can be used alone at a saving of price, but it is usually more convenient to have a separate reproducer for use by the typist. The wax cylinders can be used many times by shaving off the transcribed letters in a shaving machine. The machines are worked by a small electric motor attached to the ordinary electric lamp wire; this drives the cylinder both in dictating and transcribing.

The dictating machine saves the energy of the typist as well as of the principal. She has no worry over her shorthand notes, and a foot control enables her to retard or stop the reproduction of any part of a letter, or she can make the machine repeat any sentence or sentences. Everything is under her easy control, and she can type faster without any effort and prevent her work from keeping her in the office late at night. The sound is made audible to the typist, not by a trumpet, as in the older gramophones, but by tubes with vulcanite terminals that fit into the ears. By this arrangement the sound is practically inaudible to all but the typist using the instrument, and a room can therefore be full of clerks typing from dictaphones without the sound of the voices interrupting and confusing one and another, and without the dictation being audible to visitors.

The price of the combined dictating and reproducing Dictaphone is £21, with electric motor and many new features. The reproducing Dictaphone costs £18 18s., and the Shaving Machine 12 guineas. The Edison Dictating Machine is priced at £20, and the hand Shaving Machine at £8 10. The Parlograph combined machine with complete outfit costs from £16 15s. to £20. The Roneophone, with Pathé patents, has a correction key for re-phrasing or amending dictated matter, and a flat disc, instead of a cylinder, and a back spacer.

Where a spring motor is used instead of an electric motor, the price in all cases is less; but as a spring motor has to be wound up every 25 minutes or so, the electric drive is much to be preferred wherever electric power is available.

Letter Devices. Where a large mail is received or despatched, and where large quantities of circulars are sent out, letter folders, envelope sealers and openers are great time-savers. The Universal Folding Machine of the International Multigraph Company automatically feeds, folds, counts, and stacks from 6000 to 8000 sheets an hour. It takes paper of all kinds and thicknesses, and of varying sizes, and gives many different characters of folds. The same company sells the Markoo Electric Sealer, which automatically seals and stacks 6000 to 10,000 envelopes an hour. These may be of regular stock sizes, odd-sized specials, and catalogue envelopes.

Letter sorters are an easy method of filing a small correspondence and handling a large daily batch of letters. There are various systems. A set of expanding files lettered on the back and arranged in alphabetical order is often used; but a compact box with indexed partitions that slide along rods and adapt themselves to the different amounts of space required for each letter of the alphabet forms, perhaps, a more convenient sorter for temporary purposes. One that will hold 3000 letters costs from 10s. 6d. For the same price a series of lettered expanding files can be obtained for use as a ready sorter. Small sorters holding 300 letters cost very little.

The Standard Stamp Affixer takes stamps in rolls of 500, locks them up, and by simply pressing the handle, moistens them and sticks them on envelopes or packages at the rate of 100 a minute. The machine is light—13 oz.—being made of aluminium, yet strong. It costs £3 3s.

An even more ingenious apparatus is an adaptation of the idea to the stamping and cancelling of insurance cards. It is known as the Dragon Insurance Stamp Affixing and Cancelling Machine, and not only sticks the stamp in the right place on the insurance card, but at the same operation cancels it by printing on it the date. The stamps are, as in the ordinary stamp affixer, inserted in the form of a roll. The Post Office supplies stamps in rolls for these machines.

Small stamp moisteners for envelopes and insurance cards—fashioned like an ever-wet small brush—cost 2s.

An envelope opener for dealing with a large mail is made of an emery wheel, against which the edge of the letters is placed. It is rapid and safe.

Sealing Machine. This is a device for packing parcels without the use of twine or sealing-wax. It consists of a roll of gummed sealing tape, held in a receptacle that moistens the tape as it runs out. The "Plex" Sealing Machine costs 7s. 6d., and the gummed sealing tape is supplied in 800 feet rolls at about 1s. It makes a neater package and a securer parcel, and costs one-third as much as twine.

The Radiation, Absorption and Conduction of Heat. Thermodynamics. Conservation of Energy and Matter.

THE PHYSICS OF HEAT

Brief reference has already been made to the fashion in which heat travels. We distinguished between *convection* and *conduction*. But heat may also travel, as everyone knows, by *radiation;* and the heat so conveyed we may term *radiant heat.* The sun gives us not only light, but radiant heat; so does a fire. As we sit in front of a fire we know that air intervenes; but we also know that the space between us and the sun is not filled with air. Radiant heat is conveyed by, or consists of, vibrations, not of the air, but of the *ether*—the so-called *luminiferous* or *light-bearing* ether. Now, as we shall see later, light and radiant heat are essentially identical; they both consist of precisely the same kind of vibrations of one and the same medium. The difference between them is the same as the difference between one octave of the keyboard of a piano and another. Thus the laws and the manner of the transmission of radiant heat are in every respect identical with those of the transmission of light.

Laws of Radiation. What must we conceive to happen as a hot body radiates heat from its surface? We conceive the heat of the body to consist of a form of motion. We must regard this heat energy, which is really kinetic energy, as being transformed, at the surface of the radiant body, into the energy with which the ether around it is caused to vibrate. When some other material body is struck by these rays, they are retransformed into the previous form of heat or into heat and light.

We have said that the laws of the transmission of radiant heat are those of the transmission of light. It is true of the waves of both that they are propagated strictly in straight lines. This can be proved for heat almost as easily as for light. Similarly, it is true for both, as, indeed, for all forms of ethereal wave motion, that the intensity of the radiation, or its energy per unit of its area at any point, varies inversely as the square of the distance from the source of the radiation. We may compare this law with the similar part of the law of gravitation.

The reflection of radiant heat, again, follows the same laws as the reflection of light—as we must expect, since we believe them to be essentially identical. Again, radiant heat and light are similarly subject to refraction, when passing through a solid medium, or from one solid medium to another.

"Transparency" to Heat. We purposely employ this unusual phrase in order to insist still further upon the identity of radiant heat and light. We know that exactly as substances differ in their transparency to light, so they differ in their transparency to radiant heat—a property which is technically known as *diathermancy.* Substances which are transparent to light are not necessarily transparent to heat, however. But this fact is only another aspect of the fact of light—that light waves of different wave length are variously transmitted or reflected by various material substances. Water readily transmits light, just as glass does, but it is quite opaque to radiant heat; whereas liquid bisulphide of carbon is highly "transparent" to radiant heat, transmitting nearly two-thirds of the rays.

A classical proof of the presence of rays of heat in sunlight, and their essential identity with those of visible light, is to be found by spreading out the various waves in sunlight into a spectrum by means of a prism. Everyone knows that in such a case we see a band of colours, shading off from red to violet. If, now, a thermometer be put in various parts of the spectrum, it is found to be heated in varying degrees; but in greatest degree when it is passed quite beyond the red end of the coloured band, and exposed to the invisible heat rays which lie there.

Absorption of Radiant Heat. Just as light may be absorbed and radiated, so may radiant heat, the rule being that the absorption and radiation of bodies with dull surfaces is greater than that of bodies with bright surfaces. It must be evident that as a body radiates, it cools. If its immediate surroundings were "opaque" to radiant heat, the body could not radiate and could not cool. Other things being equal, however, we may assert that the rate at which a body cools is proportional to the difference between its temperature and that of its surroundings—that is to say, if the difference be 20 degrees, the body will cool twice as fast as it would if the difference were 10 degrees.

The importance of radiation as a cause of cooling is most marked in the case of planetary bodies. Probably owing to its small size, the moon has been unable to retain its atmosphere; hence it has been able to radiate its own proper heat with great rapidity. Furthermore, while the heat upon its surface when exposed to the sun must be terrific, on the other hand, it must radiate away such heat at a very great speed when the sun is hidden from it, producing the most intense cold. The earth is always radiating its heat into space. So far as the usually recognised constituents of the air are concerned, this heat can readily escape, oxygen and nitrogen being *transparent* to radiant heat, or *diathermanous.*

But water vapour and carbon dioxide are constant constituents of the atmosphere, and

these, being relatively opaque to radiant heat, arrest a great deal of the radiation. The reader who is interested in this subject must turn to the discussion of radium and radio-activity in the course on CHEMISTRY. We now know that the radio-activity of the earth's crust is sufficient to compensate completely for the amount of heat which it constantly loses owing to radiation.

The Conduction of Heat. We are all familiar with the fact that the thermal conductivity of different substances varies within wide limits, metals being conspicuous instances of good conductors, while most products of living matter, such as wool and bone and wood, conduct heat very badly. But metals themselves vary in this respect. Copper and silver are exceptionally good conductors of heat, as also of electricity. It is obviously necessary to invent a standard by means of which we may readily express the *thermal conductivity* of a substance. This, then, is defined as the number of thermal units which are conducted per unit of time per unit of surface through a slab of unit thickness, the sides of which differ in temperature by one degree.

Results of Differing Conductivity. We must here note some of the most obvious consequences of the wide differences that obtain between various substances in respect of thermal conductivity., The most important of these results are those which affect the bodies of warm-blooded animals. Nearly all such animals are covered with a coat made of one kind or another of non-conducting substance. Feathers are of some value in this connection, hair of greater value, wool more valuable still, and fur most valuable of all.

Man is conspicuous among warm-blooded animals in being naked, and finds it necessary to cover himself with substances having a very low thermal conductivity. The most valuable of these are all derived from the non-conducting coats of other animals. We speak of warm and cool clothing, but the reader is well aware that, according to the Laws of Temperature, all bodies tend to become equal, not in amount of heat, but in heat level. Thus all the various kinds of clothing are, in general, of the same temperature. What we call warm clothing is merely that which has a low thermal conductivity, or is a bad conductor, while cool clothing is that which has a higher thermal conductivity, or is a better conductor.

The Safety Lamp. Everyone who has spent even an hour in a laboratory must be familiar with the experiment of controlling a flame—such as the flame of a Bunsen burner—by means of a sheet of wire gauze. This gauze may be made to confine the flame beneath itself; but if the gauze be held an inch or two above the burner before the gas is ignited, the gas can be made to burn above the gauze, but the flame will not spread beneath it. The obvious explanation of this is that the metal of the gauze is a good conductor, and so rapidly carries away the heat produced that the temperature on the far side from the flame, whichever that be, is not high enough for the combustion of the gas. This fact is utilised in the famous safety lamp invented by Sir Humphry Davy. This is simply an oil lamp surrounded by a cylinder of wire gauze. If coal gas be present in the air of the mine, it will burn when raised to an adequate temperature by means of the flame of the lamp, but the gauze will prevent the flame from spreading beyond it, while the harmless burning of the coal gas affords an exceedingly important warning to the miner.

Heat and Work. We must now consider what is, in some respects, the most important aspect of the science of heat. We are already agreed that heat is not a material thing, not a fluid, or a *phlogiston*, but a mode of motion—a form of energy convertible into any other form of energy, as in an engine or an animal body. In many ways we can produce heat by doing work, as in every kind of machine, or as in the case of a savage who lights a fire by rubbing two pieces of dry wood together. The question arises whether there is a definite amount of heat that corresponds to any particular amount of work done; and the answer is that such a definite and necessary relation does exist. The famous name in this connection is that of Joule, of Manchester, and his work is about seventy years old.

The *mechanical equivalent of heat* is now frequently represented by the letter J, and this has been variously estimated since the time of Joule. The mechanical equivalent of one British unit of heat (the amount of heat which can raise one pound of water from 60° to 61° F.) is 778 foot-pounds.

Laws of Thermodynamics. The establishment of this equivalent—or, rather, the establishment of the fact that there is an equivalent—leads to the foundation of the science which is now known as *thermodynamics*, and deals with the relations between heat and kinetic energy. It is largely the study of this science which has led to the establishment of the great principle of the conservation of energy.

In accordance with this principle, what is known as the *first law of thermodynamics* states that *the amount of heat evolved in doing a given amount of work*—assuming that the work results exclusively in the formation of heat—*is constant*; and, on the other hand, that *the consumption of heat in producing mechanical energy is equally constant*. We have already stated the figure which expresses the relation between heat and work. So far as the first law of thermodynamics goes, there is absolute and reversible equivalence between heat and work; but to it we must add a *second law of thermodynamics*, which states, as we already know, that heat cannot pass from a body at a lower temperature to one at a higher. Hence, we have a new significance for temperature or heat level. We may have heat enough and to spare, but unless we have a balance of temperature in our favour we will never get any work out of it. Thus, while the first law of thermodynamics expresses the conservation,

equivalence, and convertibility of energy, the second law expresses what we may call the doctrine of the *availability of energy*.

Lord Kelvin. This second law, as well as the first, in some small measure, we owe to the genius of the late Lord Kelvin, formerly Sir William Thomson. The years 1851 and 1852 saw his contribution to the Royal Society of Edinburgh of the two classical memoirs in which the science of thermodynamics is put upon a firm foundation. At this point we cannot do better than quote from Dr. J. T. Merz, whose "History of European Thought in the Nineteenth Century" is the most valuable work of its kind in any language. He says: "It was Thomson who first clearly saw that the axiom of the impossibility of a perpetual motion would be infringed if the first law of thermodynamics—the indestructibility of energy—was accepted without the second. For practical use, for doing work, it is not sufficient that energy be not lost; it must be available—get-at-able. Energy may be in a condition in which it is useless—hidden away—and to bring it forth again may be for us either impossible (if it be dissipated), or may require an expenditure of work—that is, of energy—to do so." To this subject we must return after we have discussed the great generalisation of the conservation of energy, to which the first law of thermodynamics affords such signal support.

The Conservation of Energy. The doctrine of the conservation of energy has well been described as the greatest of all exact generalisations. The idea is far older than its proof. Indeed, the philosopher Thales, as long ago as 600 years before Christ, said (or at least is reported to have said): *Ex nihilo nihil fit* —that is, "From nothing, nothing is made." This, however, is only one-half of the doctrine, the other half being that which is alone expressed by the usual name of the doctrine. On the one hand, the doctrine denies *annihilation*, declaring that energy is persistent and conserved; and, on the other hand—as in the saying we have quoted—it denies *creation*. These two denials are equally essential and complementary parts of the doctrine.

The reader who remembers our discussion of Newton's laws of motion cannot but observe how consistent those laws are with the doctrine of the conservation of energy—in this case kinetic energy. The word *energy* was introduced by Dr. Young at the beginning of last century, but the idea which it conveys was more or less definitely present to the mind of Newton himself; and the late Lord Kelvin and the late Professor Tait have shown in addition that Newton was on the very verge of recognising completely and formulating the modern doctrine of the conservation of energy. Notably, we may recall the simple expression of his third law, that *action and reaction are equal and opposite*.

Perpetual Motion. The laws of thermodynamics teach that while energy is always conserved, it is capable of endless and indefinite transformations—as, for instance, from heat into work or vice versâ. Now, all the workers—French, German, and English—whose labours went to consolidate the science of thermodynamics used language which was incompatible with the old idea commonly known as *perpetual motion*. The phrase is an unfortunate one, because the universe must in all probability be regarded as itself a perpetual motion machine; but by the impossibility of perpetual motion is really meant not a denial of Newton's first law of motion—that is to say, the doctrine that all motion is perpetual until force interferes to alter and modify it but rather the principle that such a perpetual motion is of no use, as no work can be done with it except by using it up or annihilating it. And this statement reminds us of the second law of thermodynamics. It was all very well to assert—as various workers did assert in the 'forties of last century—that power cannot be created or destroyed, and that its various forms are mutually convertible without end, but such assertions are equivalent to saying that perpetual motion *is* possible.

Energetics. It was Lord Kelvin who first recognised "that the old phantom of a perpetual motion was turning up again in a new form." Thus we must never remember the doctrine of the conservation of energy without also recalling the subsequent doctrine that, though energy is never *lost*, it becomes for our practical purposes *unavailable*. Hence the great German scientist Professor Ostwald, in framing the terminology of the science which he calls *energetics*, describes the doctrine of the conservation of energy as the first law of energetics, and then goes on to say: "A perpetual motion could, however, be attained if it were possible to induce the large store of energy at rest to enter into transformations." The fact that this is impossible Ostwald calls the second law of energetics. We may associate it in our minds with the second law of thermodynamics which has been already stated.

Dissipation of Energy. So far as the law of the conservation and the equivalence of the different forms of energy is concerned, it would appear that these are all of the same value. When work is done, no energy is consumed—it is merely changed. Why may it not be changed back again? So far as the law of the conservation of energy is concerned, all natural processes—all mechanical processes, at any rate—must surely be reversible. But Lord Kelvin showed that this is not so. In 1851 he said—and this is practically his second law of thermodynamics—"It is impossible by means of inanimate material agency to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects."

Available and Unavailable Energy. Thomson saw that, notwithstanding the work of Joule, natural processes do not work as well backward as forward—in other words, the *Cosmos* is not a perfect machine, if even it be a machine at all. He realised that there is in Nature a general tendency toward not a destruc-

tion but a degradation or dissipation of energy. The energy is not lost, but it is lost so far as its utility is concerned. All forms of energy tend to assume the form of heat, which is the least available form of energy. For all practical purposes, and also for our philosophical view as to the future of the universe, the distinction between available and unavailable energy, or between useful and useless energy, is all-important. Other workers showed that in practically all natural processes a certain quantity of energy is thus accumulated and lost. This energy was called *entropy* by Clausius, who introduced that much-controverted term; and what Lord Kelvin had expressed as the universal tendency in Nature toward the dissipation of energy, Clausius expressed by saying "the entropy of the world is always on the increase."

The Coming of Universal Death. But what does this signify if we take a large enough view of it? It signifies that the universe is travelling toward universal death. At present there is a great difference of heat potential between the different parts of the solar system, one consequence of which is the presence of life upon the earth. But in time to come the heat will have distributed itself so that the system which corresponds to the solar system of today will be all of one temperature, and life will be impossible. The case must be the same, if Kelvin's doctrine be correct, with the whole universe. In time it will all have assumed a uniform temperature; its other forms of energy will have been resolved into heat, and the cosmic life will have run its course.

Furthermore, as natural processes are irreversible, there must be no possibility of a phœnix-like resurrection. "This remarkable property of all natural processes," says Dr. Merz, "seems to lead us to the conception of a definite beginning and to shadow forth a possible end—the interval, which contains the life or history of Nature, being occupied with the slow but inevitable running down or degradation of the great store of energy, from an active to an inactive or unavailable condition." The discovery of radium and radio-activity, and of all the hitherto unsuspected energy—available energy, too—which these reveal to us, does not militate in any degree against the doctrine of the dissipation of energy.

Doubt of the Issue. Almost overwhelming as the evidence for this doctrine would appear to be, it is yet very far from being accepted by contemporary physicists. It was not, indeed, accepted without grave reservations by Lord Kelvin himself. If, for instance, we regard the universe as a closed system, one conclusion emerges, and, if not, another emerges. We do not in the least know what is the destiny of the heat and light energy which are incessantly being radiated from the solar system. When the doctrine of the dissipation of energy was framed, there was scarcely any conception of the idea, now current amongst astronomers, that the universe—or, rather, *our* universe—may be finite. We are now entitled to suggest that, even if *our* universe be running down, something may be going on elsewhere which shall wind it up again.

The Conservation of Matter. As the reader on the course on CHEMISTRY has already learnt, the doctrine of the conservation of matter can no longer be maintained—at any rate, in its original form. But the doctrine of the conservation of energy stands—"this grand principle," as Professor Tait used to call it. Recognising that the law of the conservation of matter must really be regarded as only an aspect of the law of the conservation of energy, Herbert Spencer formulated the phrase *persistence of force.* But force, as the reader knows, is a term now used in a special sense by the physicist, and so Spencer's term has not gained currency. Professor Haeckel, of Jena, included the doctrines of the conservation of energy and the conservation of matter under the term the *law of substance*—meaning by "substance" the thing that stands under—the underlying something. This is really another name for Spencer's persistence of force. If, now, we turn back from Spencer to Thales, whom we have already quoted, we see the importance which philosophers have attached to the conception that there is at bottom some kind of reality which is eternal, and which, however many transformations its appearances may undergo, suffers neither increase nor loss.

Our Conclusions Summarised. Here we must conclude the most fundamental and philosophically important part of our subject. The great truths which we have learnt so far may thus be summarised. We have learnt to suspect that causation is universal; we have learnt to recognise the equivalence, the capacity for transformation, and the ultimate identity, of many things which appear to be different. Our coming study of sound and light will add to the number of these. We have learnt, that is to say, to recognise unity in multiplicity, ultimate identity in apparent variety. We have learnt to question the possibility of annihilation or of creation out of nothing. We may even be inclined to admit that these processes cannot really even be conceived.

Finally, we have seen how, within the last hundred years or thereabouts, physicists have placed upon the foundation of observation and of exact experiment this doctrine *Ex nihilo nihil fit*, which was first framed, and has been for ages maintained—not on the grounds of any observations or experiments whatever, and in contradiction, indeed, of appearances, such as those of apparent destruction by fire—but which was, in the first place, based upon a law of the mind which compelled it to believe that something could not be created out of nothing nor ever reduced to nothing. This part of our subject has therefore led us to the confirmation of an *a priori* or necessary truth by the special method which is characteristic of science, and which is known as the *a posteriori* method of reaching general from particular truths.

C. W. SALEEBY

The Use and Construction of Raking and Flying Shores, and of Needles for Underpinning. Methods of Dealing with Dangerous Structures.

SHORING AND UNDERPINNING

SHORING consists in providing temporary support to a building by means of a system of wooden struts resting on solid ground or against another building. It is employed in cases where buildings show signs of failure due to sinking of the foundations, vibration of machinery, or other causes, and demands much judgment and very great care in execution.

It is also used where a building which is attached to one or more other buildings is to be taken down for rebuilding. In a row of houses —*e.g.*, each one gives lateral support to its neighbours, and were a single house in a row removed there would be great liability of damage to the houses which are on each side, and are entitled to the support previously afforded them, and shoring is erected to give this support temporarily until the reconstruction is complete.

A Typical Shoring Scheme. The key plan [63] represents three houses in a line, of which the central one is in course of reconstruction, while that on the left is to have the ground-floor taken out to insert a girder and shop front. It illustrates the position in which the various shores described hereafter are used.

Shores, as applied to walls constructed mainly of brick, are of two principal types. *Raking shores* [61] are those one end of which rests on the ground, while the other is inclined against the face of the wall to be supported. *Flying shores* [59] are those placed horizontally between two buildings. In the case of raking shores, if the building to be supported be a low one, a single strut may suffice, but in most cases, where the buildings consist of several storeys, a *system* of shores must be used—two or more struts in the same plane, abutting against and steadying the wall at different levels. Wherever possible, the head of each strut should be arranged at or just below the level of a floor, where the wall is stiffened internally and is best able to resist external pressure. The object of shoring in the case of dangerous walls is not, as a rule, to force back into position a wall that is out of the perpendicular, for any such attempt might result in disaster, but to prevent any further movement of the wall till it can be dealt with in a permanent manner.

Constructing a Shore. A shore is constructed as follows [64]. A wall-piece is placed vertically against the wall to be supported. This is usually of considerable length, 9 by 3 in. thick, and is held to the wall by holdfasts carefully driven. If the wall be bulged or uneven, packing must be placed between it and the wall-piece to secure an even bearing against the wall. Where the head of the shore abuts [58], a 3 or 4 in. square hole is perforated through the piece, and a bat or half brick is removed from the face of the wall. A short timber, or *needle* is placed through the hole entering the wall where the bat is removed, and above it a block of wood, termed a *cleat*, is spiked to the wall-piece, and thus a firm abutment for the head of the shore is formed.

For the foot of the shore [60] a stout timber is provided, termed the *sole-piece*. If the ground be good, it may be carefully bedded upon it; but if the ground be soft, a small platform of stout planks, or in some cases even of concrete, will be necessary. Should a vault exist where the foot of the shore comes, it must be supported with dead shores—hereafter described—or, better, the shore must be taken through the vault to the solid ground. The sole-piece is not placed horizontally, nor is it perpendicular to the shore, but at an intermediate angle.

The sole-piece and wall-piece being in position, the shore itself is cut to the required length. The head is notched to fit round the needle and prevent any possibility of lateral movement, and the underside is cut so as to rest against the wall-piece. The foot is also cut to a bevel to correspond with the inclination of the sole-piece, and at the back of the shore a small notch is cut to allow of a crowbar being inserted. The shore is placed in position, and if the wall be dangerous great care must be exercised to prevent any damage to the wall during this process. The foot rests on the sole-piece with the head against the needle, at first loosely, but with the help of a crowbar the foot is gradually moved forward along the sole-piece until the notch is tight up against the needle. If it be moved beyond this, there will be a tendency for the head to lift the needle and damage the wall. When in position the foot is secured by *dog-irons* [57]. These are bars of iron with ends bent at right angles and pointed. They may be driven into the foot and the sole-piece, or a cleat may be fixed behind the foot. In the case of dangerous walls this method of fixing is better than tightening by wedges as less likely to disturb the brickwork. The shore is stiffened to resist transverse strain or buckling, by braces formed of boards placed on either side and securely nailed to it at one end, and to the lower part of the wall-piece at the other.

A System of Shores. Where a system of two, three, or four struts—one above another —is employed, the method is similar [61]. The length of the wall-piece is increased to correspond with the height of the building, and the head of each shore is prepared as described, and has a needle provided for its abutment. The feet are

brought close together on the sole-piece, and each shore in the system is of a different length and at a different angle. In such a system, when the shores are in position, a strip of hoop-iron is wound tightly round near the foot and nailed to the various timbers, binding them together, and the braces extend from the wall-piece to the outermost shore, and are nailed to the intermediate ones. This occurs at two or three points in the height in each case, starting from the wall-piece just below the head of a shore. Great rigidity is thus secured.

Shoring High Buildings. With lofty buildings it may prove difficult to obtain timbers of sufficient length for the outermost shore. In such a case, when the last raking shore is fixed, another piece of timber is placed against the back of it, resting on the sole-piece. The top is cut to a bevel, and the foot of the shore rests on the top of this post, the head being formed as usual. This is termed a *riding shore*, and cannot be levered into position, but must be wedged with folding wedges of oak inserted between the upper and lower parts of the shore, driven in from each side, care being taken not to lift the rider more than is required just to tighten it.

The number of such systems required to steady any given wall will vary with the circumstances, and in particular with the condition of the wall itself, depending on whether the brickwork is sound and well constructed, or tending to disintegrate. They should not be more than 12 or 15 ft. apart, and may be much closer. If the wall is pierced with window openings, the shore systems must correspond with the piers between them.

Shoring is sometimes required in connection with the timbering of excavations. The horizontal struts used in wide excavations form practically flying shores, which will be described later; but an excavation may be too wide to allow of strutting each side from the opposite one. In such cases raking struts, or shores, must be provided to sustain the walling pieces, and they can often be used with greater efficiency than in the case of a building, as it is frequently possible to place them at a comparatively low angle with the horizon.

Work of the Shore. The work required of a shore, or shore system, is to resist the tendency of a wall to fall outwards, by pressure behind it, which is greatest when just sufficient to overturn the wall. This pressure, or force, acts perpendicularly to the wall through the head of the shore. It would be best resisted by a strut also perpendicular to the wall; but, except in the case of flying shores, this cannot be provided. With a raking shore part of the force exerted is expended in holding up the wall vertically, and part only in resisting overturning, the amount depending on the inclination of the shore to the horizon, the lateral resistance being greatest when the inclination is low. An angle of 40° is useful, but so low an angle is rarely practicable, and angles from 60° to 75° with the horizon are very usual.

Formula of Forces in a Shore. The following formulæ may be used for calculating the forces acting upon a shore [64]. *

$$Q = \frac{W \times t}{2\,H},\ P = Q \tan\theta - \frac{w}{2},\ F = P \sin\theta + Q \cos\theta$$

Q = the overturning force, P = the force due to weight of wall above shore, F = the resistance to compression in the shore, W = the weight of wall, all in cwts., t = the thickness of wall at ground in feet, H = the height of the head of the shore from the ground in feet, θ = the angle of inclination between the shore and the horizon, and w = the weight of the shore itself in cwts. The dimensions of the shore, when F has been calculated, may be found by Rankine's or other formulæ for timber struts.

In a system of shores it is sufficient to calculate the outermost shore, and to use timber of the same size for all, and a builder will usually employ timber in stock for this purpose even if of somewhat larger scantlings than required.

The number and sizes of shores usually required in each system are: *

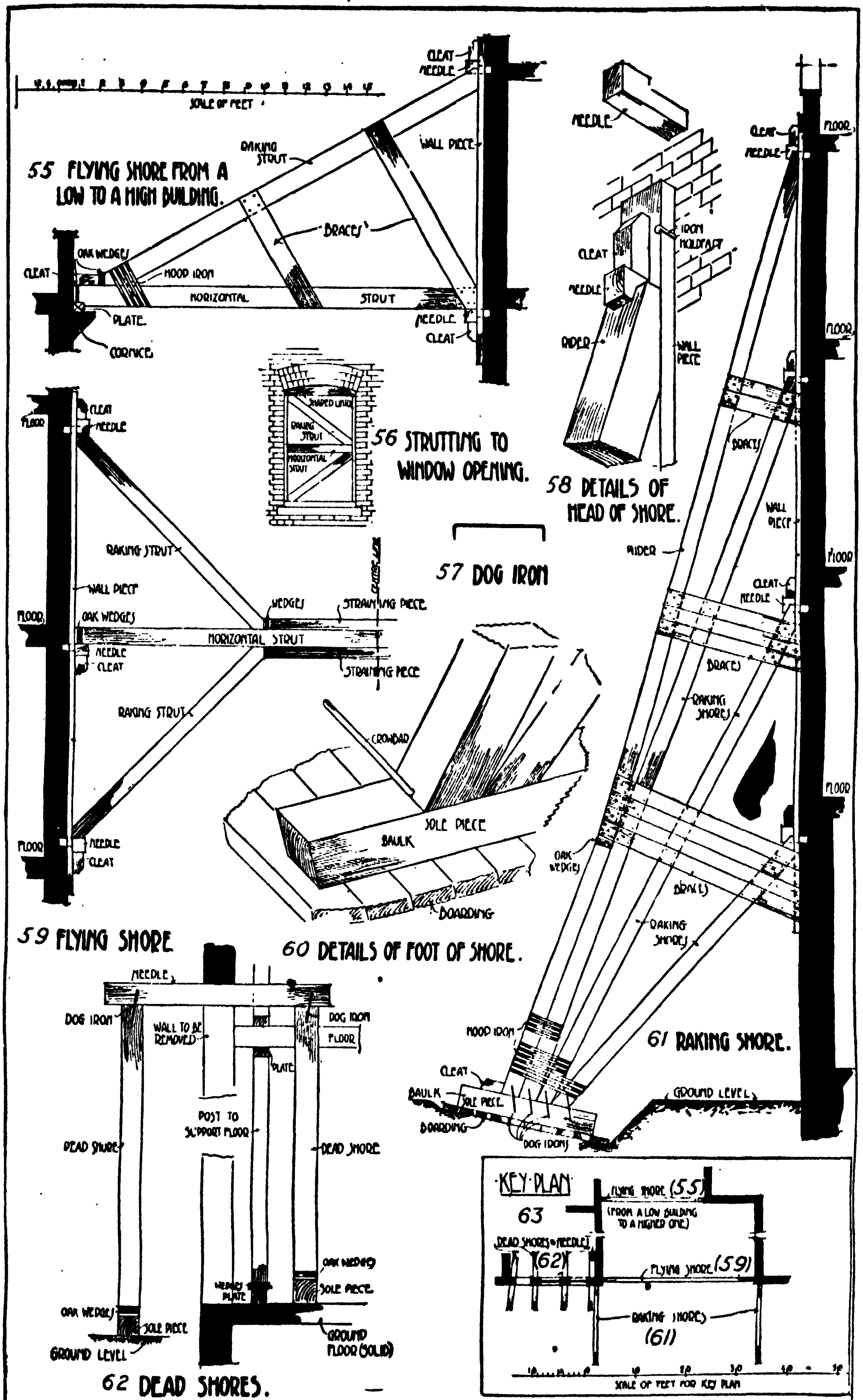
Height of wall.	Number of shores in system.	Scantlings of each shore in system
15 ft. to 20 ft.	2	5 in × 5 in.
20 „ „ 30 „	2	6 „ × 6 „
30 „ „ 35 „	3	7 „ × 7 „
35 „ „ 40 „	3	8 „ × 8 „
40 „ „ 50 „	4	9 „ × 9 „
50 upwards	4	12 „ × 9 „

The material used for shoring is usually fir, Dantzic being particularly suitable on account of its straight grain. For very long shores, however, it may be difficult to obtain this timber of sufficient length, and pine is sometimes used. But this is more expensive, and is therefore avoided, when possible, for what is merely temporary work. The wedges should be of oak, as offering greater resistance to compression than fir, and the sole-piece may usefully be of the same material. Care must be taken to see that all bearing surfaces are truly cut, so that when in position they will be in contact all over.

Flying Shores. *Flying*, or *horizontal* shores [59] are employed wherever a suitable abutment can be secured above the ground level. Their most common use is when a house between two others is temporarily taken down and the buildings on each side require mutual support, but they may be employed across a court or street in the case of a dangerous building, with the consent of the owner of the opposite building, who is, however, at liberty to withhold it.

The great advantage of a flying shore is that the principal timber is placed perpendicularly to the face of the wall, and therefore directly counteracts the overturning force.

* C. Haden Stock. "Shoring and Underpinning."



55-63. DIAGRAMS ILLUSTRATING SHORING

Construction of a Flying Shore. Where a flying shore is used, a wall-piece is fixed against each wall as for a raking shore, the horizontal timber is fitted between the two plates, the ends carried on needles, and folding wedges are inserted between the end and one wall-piece and driven in to tighten it between the walls. In the simple form of flying shore straining pieces are placed above and below this beam at its centre, from the end of the lower one, struts are inserted extending downward to the lower part of the wall-piece, the heads abutting against needles as in an ordinary raking shore; from the upper straining piece similar struts extend upwards. These struts are all cut as close as possible except one of the upper pair, and between the end of this strut and the straining-piece folding wedges are driven in until the principal timber is slightly deflected, all the struts are tightened, and the beam is rendered stiff.

Such a beam with upper and lower struts will serve to strut a building at the level of three separate floors. If it be required to strut four floors, two horizontal beams are used, and placed opposite the second and third floors to be strutted, and the straining pieces are fixed one below the lower beam and one above the upper beam. Vertical posts are placed between these beams between the ends of the straining pieces, and the raking struts are inserted and tightened, as already described. If more than four floors require strutting two separate flying shores may be placed vertically one above another, with a continuous wall-piece if possible.

Shoring Walls of Unequal Height. A somewhat similar arrangement may be used where the buildings are not of equal height [55]. The horizontal timber is placed at or near the top of the lower building, and the upper part of the taller building is supported by raking struts from the opposite end of the beam instead of from a straining piece.

The horizontal timber must always be in a single length, as it is subjected not merely to compression but to cross-strain, and if fir timber cannot be obtained of sufficient length for wide spans, pine may have to be employed.

The sizes usually employed for flying shores when the horizontal timber is placed at a height of about three-fourths of the distance from the ground to the top of the wall, and not more than from 10 to 15 ft. apart, are as follows. For spans under 15 ft., horizontal timber, 6 in. × 4 in.; raking struts, 4 in. × 4 in. For spans between 15 and 33 ft., horizontal timber, 6 in. × 6 in., up to 9 in. × 9 in.; raking struts, from 6 in. × 4 in. to 9 in. × 4½ in.

Where flying shores are used for supporting the flank wall of a building, it is often desirable to steady the front and back-end of such a wall with raking shores.

Underpinning. Underpinning in order to lower the foundations of walls is described later in this course under BRICKLAYING. If the wall to be dealt with is seriously out of perpendicular, or badly cracked, or if, for any other reason, it be desired to remove entirely for a time the lower part of a wall without disturbing the superstructure, then a different course must be pursued. This consists in supporting the upper part of the wall by passing large horizontal timbers, termed *needles*, through holes formed in the wall, and supporting the two ends of the needle on vertical posts or *dead shores* [62]. These needles should not be more than 5 to 7 feet apart, and should always be placed under a pier, not under an opening.

Any overhanging piers or chimney breasts will require special attention and support; where the object is to insert a girder to carry the superstructure then needles must be placed above the level of the floor below which it is intended to insert the girder. For this work square timbers of large size are used, generally about 12 in. square. Solid bearings for the feet of the dead shores must be provided, and may be formed of a timber sleeper or cill; the shore at the inner end of the needle must pass through the floor so as to support it directly. Folding wedges may be used between the foot of the shore and the sleeper to raise the needle, and press it tightly against the brickwork it is to support. Screw-jacks, or hydraulic jacks are sometimes used in preference to wedges.

Shoring the Floor Joists. If the floor joists rest upon the wall to be dealt with they must be strutted by a series of smaller dead shores resting on a plate below, and having a head below the ceiling level. These must be wedged up to take the weight of the floor off the wall, and jacks are specially useful in this work. Any upper floors, if there are more than one, should be dealt with in the same way, so that all possible weight is removed from the wall itself.

The main dead shores or those used under the floor may be formed in two heights if there is a difficulty in introducing the necessary large timbers in a single length into the building. In this case an intermediate plate or transom is introduced at about half the height, extending through all the needles parallel to the main plate and perfectly level, and the wedges may be introduced above this beam.

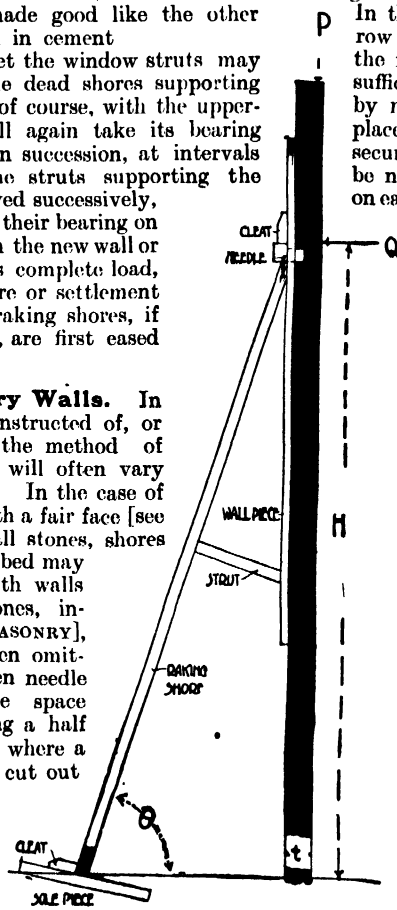
Strutting Window Openings. The window openings in the upper part of the wall must also be strutted [56] with cross struts to prevent the risk of their becoming distorted. If the wall is insecure raking shores may be required to steady the upper part, but where a girder is being inserted in a sound wall these may, as a rule, be dispensed with. When all the needles are in position, and care must be taken to see that they will not interfere with the work to be carried out, the wall may be taken down, leaving the upper part supported by the needles and shores. If the wall is to be rebuilt, this can be taken in hand as a whole; or, if a girder is to be inserted, piers may be built to carry the ends of it, or stanchions, or wooden storey-posts inserted. As soon as the piers, or stanchions, are ready, the girder is put into position, and is then usually covered with slabs of stone from 3 in. to 6 in. thick, called *cover stones* [see BRICKLAYING], the full width

of the wall, and upon this brickwork is built in cement under the lengths of wall between the needles, and the new brickwork is pinned up tight under the old. If possible, the levels should be adjusted so as to allow of an exact number of brick courses being used, but if this is not possible the necessary thickness may be made up with hard slates or tiles set in cement.

Striking Underpinning and Shoring. Seven days are usually allowed for setting, then the needles are gradually eased by loosening the wedges or lowering the jacks, so that the wall takes its bearing on the girder. They are afterwards removed, and the holes occupied by them made good like the other parts with brickwork in cement

When this also is set the window struts may be taken out, and the dead shores supporting the floors, beginning, of course, with the uppermost floor, which will again take its bearing on the wall. Then in succession, at intervals of a day or two, the struts supporting the lower floors are removed successively, and they in turn take their bearing on the wall; lastly, when the new wall or girder has received its complete load, and no signs of failure or settlement are observable, the raking shores, if they have been used, are first eased and then struck.

Shoring Masonry Walls. In the case of walls constructed of, or faced with stone, the method of applying the struts will often vary from that described. In the case of rubble walls built with a fair face [see MASONRY] and of small stones, shores similar to those described may be employed; but with walls built of larger stones, including ashlar [see MASONRY], the wall-piece is often omitted. The small wooden needle which fits into the space occupied by removing a half brick is not suitable where a large stone has to be cut out In this case a header of hard stone is inserted and allowed to project beyond the face of the wall, and beneath it a piece of oak is placed, to form a seating to receive the head of the shore.



64. DIAGRAM OF FORCES ACTING ON A SINGLE SHORE

Occasionally when great strength is required at some point in a wall, two systems of shores may usefully be employed close together; in such a case the systems are advantageously arranged not parallel to each other in vertical planes, but converging so that where the struts impinge upon the wall they are close together, while the feet and the sole pieces they rest in are wider apart, and if two such systems are well braced laterally, great strength and stiffness is secured.

Shoring Ruinous and Dangerous Structures. The method of dealing with ruinous and dangerous buildings will vary greatly with the nature of the structure and the extent and nature of the failure or damage. This is liable to so much variation that nothing but very general particulars can be given. The first essential is to steady and uphold the building to prevent its collapse. For this purpose raking or flying shores are usually employed. When the building has been temporarily secured, needling may take place to enable defective foundations or lengths of walling to be removed and reconstructed.

In the case of buildings supported on a row of detached piers or arches, in case of the failure and cracking of a pier, it may suffice to uphold the capital of the column by means of a strong frame of timber placed round it and strutted up from a secure base; but in other cases it may be necessary to shore up the two openings on each side of it upon a strongly-framed centre, such as is used for constructing an arch, and which will be described later.

Old Buildings. In all cases in which old buildings require to be dealt with, it is very necessary that they should be carefully examined, and the condition of the materials and structure ascertained, not merely on the surface of the wall, but in its heart. In many mediæval buildings walls are found constructed with a comparatively thin external skin of good masonry, while the heart of the wall is formed of rubble or concrete; if the lime used in forming the concrete was not originally of good quality this may have disintegrated. In such cases it is impossible to employ needling unless the core can be first rendered solid by the introduction of grouting [see BRICKLAYER]. It will usually be necessary to compute carefully the weight of the old building or the part of it which is to be dealt with; this is particularly necessary where any building of considerable height such as a tower has to be upheld, as the loads to be supported may be considerable. In such a position, too, there is often very considerable difficulty in finding adequate room for the necessary supports without seriously encroaching on the working space and rendering the work of reconstructing those parts of the structure that have to be reinstated extremely awkward and difficult. With structures of great height and weight the work may sometimes be quite as economically done by taking down and reinstating the work as by shoring and underpinning it; other considerations than cost may however render the latter course the better one.

R. ELSEY SMITH

THREE STAGES IN THE CYCLE OF BLACK RUST

187. WINTER SPORES OF WHEAT-RUST BREAKING FROM A WHEAT-STALK IN SPRING

188. ÆCIDIOSPORES IN AN OPENED CLUSTER-CUP ON THE LEAF OF THE BARBERRY

189. UREDOSPORES BEING PRODUCED ON A WHEAT-LEAF FROM SPORES FROM BARBERRY

Crop Diseases the Cultivator must Fight.
Well-tried Preventive Measures and Remedies.

RAVAGES OF PLANT PESTS

There are many plants which justly receive the name of "pests," because in one way or another they interfere with the work of the cultivator or breeder, and reduce his profits. Such pests may simply compete for food, air, and light with the crops, or they may be of parasitic nature, living on or in some unfortunate plant or animal "host."

The undesirable higher plants known as weeds are considered in the course on AGRICULTURE [page 837]; they are usually lawless competitors for food, though some of them, such as clover dodder, are parasites which suck the juices of their hosts.

Most plant pests, however, are lowly forms belonging to the great group of fungi [page 228], the members of which, being devoid of the green colouring matter known as chlorophyll, are unable to live on carbonic acid gas, water, and simple mineral substances, and are thus obliged to prey on green plants (or it may be animals) as parasites of more or less injurious nature. These fungoid pests are so exceedingly numerous that it will only be possible to describe a small number of them. Many others are dealt with in text-books, and also in some of the leaflets gratuitously issued by the Board of Agriculture.

The Ruinous Rusts. Rusts are excessively destructive pests which attack cereals and grasses, their name being derived from the fact that at a certain stage their presence is revealed by the appearance of rust-red streaks on the leaves and stems. They cause enormous monetary loss to the farmer, as is sufficiently attested by the fact that in 1891 Prussia alone was out of pocket by their attacks to the amount of something like £20,000,000, a sum sufficiently large to establish a respectable fleet. Yet for 1913–14 the cost of administration of our English Board of Agriculture and Fisheries, with all its innumerable activities, was estimated at the paltry sum of £309,532, and the establishment some time ago of a Development Fund of £500,000 a year for five years was regarded as a miracle of enterprise, which indeed it was—relatively. And yet agriculture is, and ever will be, "our most important industry," to say nothing of the harvest of the sea.

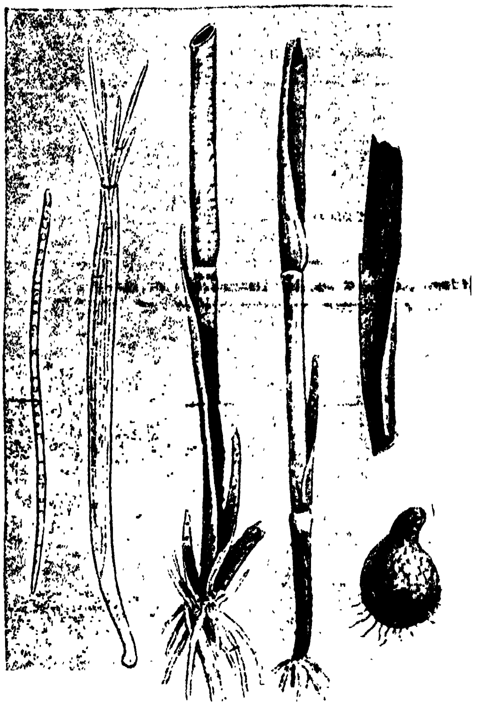
Black Rust. Black Rust (*Puccinia graminis*) [**195**], which attacks wheat and other cereals, and also grasses, although not the commonest, is one of the most interesting of its kind. The body of this pest consists, as in many other cases, of microscopic branching threads (*hyphæ*) which burrow below the surface and are collectively known as a *mycelium*. During June and July black rust grows so actively that longitudinal cracks are formed in the skin of the wheat or other infested plant, and these take on a reddish colour owing to the formation of stalked reproductive bodies (*uredospores*) of rusty hue. These spores are easily detached and dispersed by the wind, to infect other plants.

Later on in the season, the disease patches turn black, owing to the formation of curious stalked winter spores (*teleutospores*) of that colour. These remain dormant during the winter in straw and stubble, germinating in the spring, to produce minute rounded spores (*sporidia*) [**187**] which are not able to infect cereals or grasses, but if blown on to the leaves of barberry are able to develop further, the result being rounded, orange-coloured "cluster-cups" on the under sides of the leaves. Within these still another kind of spore (*æcidiospore*) is produced in large numbers [**188**]. Such spores will grow no further on the barberry, but, when transferred to wheat and the like, germinate and give rise to a mycelium, from which uredospores arise [**189**], the life-cycle thus beginning again. We see, therefore, that the same pest attacks two different "hosts" at different stages in its life, and this is quite a common occurrence, not only in parasitic fungi but also in some of the lower animal pests.

Yellow or Spring Rust. Much commoner than the last species is Yellow or Spring Rust (*Puccinia glumarum*), in which the infected patches, producing uredospores, make their appearance comparatively early in the year, and are of pale yellow colour. Black teleutospores follow in due course, but there does not appear to be an æcidial stage, the parasite attacking but one kind of plant, which may be wheat, barley, rye, or some kind of grass.

White Rust. White Rust (*Cystopus candidus*) is a most destructive fungus [**191**] which infests cabbages, radishes, and other cruciferous plants, its presence being indicated by snow-white patches, often arranged in a concentric manner, on leaves and stems; also by thickenings and deformations. Every white patch is a manufactory of chains of spores (*conidia*), within each of which numerous motile zoospores are formed, as in potato disease, which is described below. Hard-coated resting spores (*oospores*) are also formed by a sexual process, and these tide over the winter, giving rise to broods of zoospores in spring. The obviously diseased parts of the crop should be carefully collected and burnt, and the cruciferous weed shepherd's purse (*Capsella bursa-pastoris*), which plays a great part in disseminating this pest, should be eradicated so far as possible.

Different varieties of wheat, the chief cereal attacked, are susceptible to rust in varying degrees. By working on Mendelian lines, Professor



190. WHITE-HEAD, OR TAKE-ALL.
1. The appearance of the fungus at the base of oat-plants. 2. Fungus on a leaf-sheath. 3. Perithecium, or fruit of the fungus. 4. Ascus with spores escaping. 5. Spore.

Rowland Biffen, at Cambridge, has been able to produce a variety which is both "rust-proof" and of high commercial value. Much can also be done by way of prevention if sound farming methods are adopted and infected straw burnt, instead of being used for litter which later will be brought on to the land in farmyard manure and become a source of infection. Black rust is, of course, favoured if barberry bushes are permitted to grow near a crop liable to attack.

The Ravages of Smuts and Bunt. Smuts are fungoid pests which blacken and destroy the ears of oats, wheat, and barley. The black dust produced consists of innumerable spores. Oat Smut (*Ustilago avenæ*) [**197**] is transmitted by diseased grain, but the pest can be kept in check by "pickling" seed-corn with dilute copper sulphate or formalin. In the cases of Wheat Smut (*Ustilago tritici*) and Barley Smut (*U. nuda* and *U. tecta*) it is probable that the infestation is not transmitted by diseased seed-corn, for young flowers are attacked, not the seedlings. Pickling would therefore appear to be useless, but the destruction of diseased ears is desirable, as in smuts generally. Some of the grasses are also attacked, so that here, as generally, arable land should be kept as free as possible from plants other than the crop.

Bunt (*Tilletia caries*) [**193**] is related to smut, but is distinguished by the greasy nature and evil odour of the spores that fill the infected grains. Wheat, barley, and maize all suffer from this pest, and pickling the seed-corn is an effective measure of prevention.

How Ergot is Spread. Ergot (*Claviceps purpurea*) [**194**] attacks various grasses and cereals, rye being notable among the latter. An "ergot" (French for cockspur) is an elongated, purplish-black body of hard texture, which takes the place of a healthy grain, and has attained its full size at the beginning of July, or rather later. It is the resting stage of the fungus, remaining dormant on or in the ground during the winter, and germinating in the spring, to produce a number of stalked bodies with swollen heads (*stromata*). Sunk within the surface of the latter are numerous groups of spindle-shaped tubes (*asci*), within each of which from six to eight needle-shaped spores are produced. These are liberated when ripe and dispersed by the wind, some of them falling on the flowers of a suitable host, where they germinate, to produce branching threads giving rise to innumerable rounded spores (*conidia*). At the same time a sweet sticky fluid (honeydew) exudes, which attracts flies that unconsciously carry the dust-like spores from flower to flower, ultimately to destroy the grains and to develop into ergots. As these cause cows and ewes to give birth to their young prematurely, ergoted grasses should be destroyed so far as possible, and it is needless to say that grass or other seeds containing ergots should not be sown unless these are removed.

White-head or Take-all. White-head (*Ophiobolus graminis*) is a destructive fungoid pest attacking wheat and oats, often leading to the destruction of as much as half the crop [**190**]. A plant affected by white-head grows to its full size, but is dead and bleached, and only produces shrivelled grains. The blackened base of the stem marks the seat of the disease, and gives rise, later on, to little, hardened bodies, in which spore-cases and spores resembling those of ergot are produced. Take-all is the same pest; it attacks young plants, killing them at various stages. Preventive measures depend on the fact that small quantities of superphosphate, sulphate of ammonia, or phosphate of ammonia arrest the growth of the fungus.

American Gooseberry Mildew. This is a highly destructive, notifiable disease due to a fungus (*Sphærotheca mors-uvæ*), and first noticed in this country at the beginning of the present century. It forms a whitish mildew on the opening leaf-buds in spring, and this spreads to the adjacent parts of the plant, producing myriads of dust-like spores (*conidia*). Toward the close of the year a dark colour is assumed, and minute hard "winter fruits" are developed. Within these large numbers of egg-shaped spores are formed, which spread the infection in spring. The only radical cure is destruction of diseased gooseberry bushes.

Clover Sickness. One kind of clover sickness (*Sclerotinia* disease) is due to a fungoid pest, which manifests its presence by producing hard black "fruits" (*sclerotia*) at the base of the infected plant [**192**]. As in some of the forms already described, these are capable of remaining

dormant during the winter, giving rise in spring to stalked bodies with cup-shaped ends, where numerous spores are produced. Infested plants are yellow, stunted, and abnormally thickened. Land infected by sclerotia must be kept free from leguminous crops and weeds for several years.

Potato Disease. Potato disease, which at various times has completely ruined the potato crop, is due to a fungoid pest (*Phytophthora infestans*), which blotches the leaves, blackens and shrivels the stems, and rots the tubers. It is easily recognised, at an early age, by the presence of brown spots with white edges on the under sides of the leaves. It is here that the parasite, burrowing in the internal tissues, sends out branching threads into the air. At the end of each branch an egg-shaped spore (*conidium*) is produced, which is readily detached and carried away by the wind, to spread infection. It may either germinate directly or its contents may divide into a number of still smaller spores (*zoospores*), each of which is provided with a couple of slender threads that, by lashing movements, enable the spores to swim in the films of moisture present on the potato plant.

Fighting Potato Disease. Some varieties of potato are less susceptible to the attacks of this disease than others, and these should be favoured in cultivation. Diseased plants ought to be burnt, and only absolutely sound tubers employed for the purposes of propagation. Spraying with Bordeaux mixture—a weak solution of copper sulphate to which quicklime has been added—is very effective, both as a preventive and a remedy, and it has the advantage also that it greatly stimulates the growth of the crop. Late spraying may be recommended as against earlier treatment, and it is probably a waste of money to spray both early and late.

191. WHITE RUST

192. CLOVER SICKNESS—SCLEROTINIA DISEASE

1. Root of clover plant with sclerotia 2. A sclerotium producing fruit. 3. An ascus, containing eight spores.

Damping off. This is a disease which infests the seedlings of cruciferous and some other plants, and is favoured by undue moisture, as, for example, in greenhouses. It is caused by a fungus (a species of *Pythium*) which attacks the bases of seedlings, causing them to fall over and die. As the soil gets infected by spores, the same crop should not be grown continuously after the disease has made its appearance.

Wart Disease, or Black Scab. This pest (*Chrysophlyctis endobiotica*) attacks potatoes, especially when grown year after year in the same ground. Its ravages have been so serious of late years that it has been made a notifiable disease. Black warts appear on the tubers and fuse together into irregular masses. The leafy shoots above ground may also be affected. Microscopic examination shows that the fungus consists of isolated rounded cells, within some of which motile zoospores are formed. These make their way into the soil, to serve as agents of infection. Other cells become thick-walled *resting spores*, which remain dormant through the winter and germinate in spring.

Fortunately, some kinds of potato resist the disease better than others, though none appear to be entirely immune. As the infection is spread both by seed potatoes and in manure, care

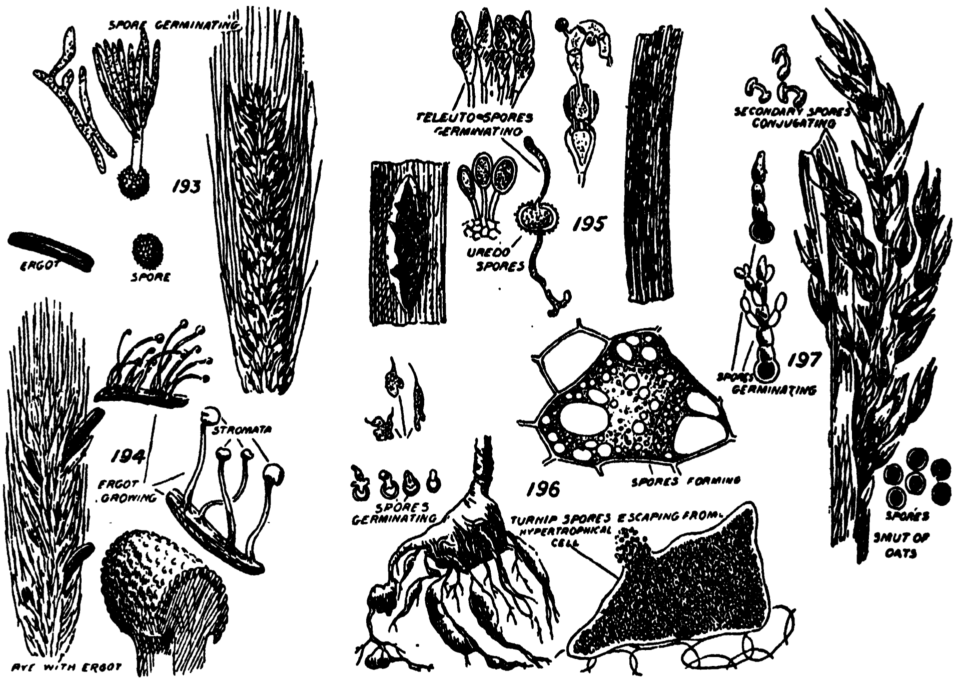
should be exercised to secure that these are not infected. In the case of an outbreak the crop should be lifted and destroyed, though unaffected or slightly affected tubers can be fed to stock, provided they are first boiled. Potato growing should be discontinued for some years on the infected area—though it is often difficult to carry out this recommendation—and the soil treated with gas-lime or flowers of sulphur.

Club Root, Anbury, or Finger-and-Toe. This nuisance (*Plasmodiophora brassicæ*) is a fungoid disease attacking turnip [196], cabbage, and other cruciferous plants, producing characteristic swellings and deformations. The shapeless body of the parasite fills the infected cells of the swollen parts, giving rise to an enormous number of exceedingly minute rounded spores, which get into the soil and spread the disease. Infected plants should be burnt, and a dressing of lime applied to the land, by which means the spores in the soil will be destroyed.

Fungus spreads Cattle Disease. Fungoid pests mostly attack plants, but there are some causing serious diseases among animals. Actinomycosis, or hard tongue, in cattle is due to the ray-fungus (*Actinomyces*), which causes the tongue to become swollen and hard, and also gives rise to nodules and tumours. Infection is contracted by eating grasses or cereals (especially barley) on which the fungus is growing. The chief preventive measures are drainage of land and avoidance of barley straw for feeding young stock. The disease yields to treatment, but this is the affair of the veterinary surgeon.

Salmon Disease is due to a fungus (*Saprolegnia ferox*) which grows in the skin and produces raw places, from which highly infectious spores are detached. Every opportunity should be taken of destroying fishes found to be suffering from the disease in question.

General Remarks on Fungoid Pests. Sound, up-to-date farming is by far the best means of maintaining the health of crops. By the adoption of a suitable rotation, pests of particular kinds are prevented from obtaining a hold on the soil, and judicious manuring—always excluding infected farmyard manure—ensures health and tides over the critical early stage. Some manures, as already explained, destroy spores and check the growth of pests. The eradication of weeds is an important matter, for these often harbour the early stages of parasites. One very hopeful modern direction of advance consists in the breeding of varieties, such as rust-proof wheat, which are immune to notorious fungoid pests. We also realise that there is valuable research to be done by way of devising spraying mixtures able to kill various pests without injuring the crops, for if Bordeaux mixture can keep potato disease in check without injuring the potato plant, there seems no reason why other fungi should not succumb to other compounds.



193. BUNT. 194. ERGOT. 195. BLACK RUST OF WHEAT. 196. FINGER-AND-TOE. 197. OAT SMUT

Bacterial Diseases. These are dealt with in the course on BACTERIOLOGY, but it may here be noted that in this case animals are the chief victims, and the large majority of their infectious or contagious diseases are of a bacterial nature. There are, however, some plant diseases due to certain of these microscopic foes, potatoes and cruciferous crops being particularly liable to attack, while the flowers of some fruit-trees, apple in particular, may also suffer from these insidious organisms.

J. R. AINSWORTH-DAVIS.

Electric Motive Power. Continuous Current Motors.
The Propelling Drag. Torque. Voltage and Speed.

THE ELECTRIC MOTOR

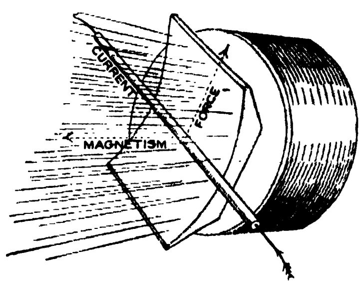
Electric Power. An electric motor is a machine for transforming electric into mechanical energy. As made today, it is a very efficient tool, converting in many cases 85 to 90 per cent. of the electrical energy supplied to it into useful mechanical work. The principle underlying its action was discovered by Faraday in 1822, when he succeeded in causing a conductor carrying a current to rotate round the pole of a bar-magnet. This conductor was supported at its top end, but was free to move, because its lower end was dipping into a pool of mercury surrounding the magnet. It is well to remember that it is not the magnet pole attracting and repelling the armature conductor which causes a motor to work. The action is a lateral one, the magnet pole tending to urge the conductor laterally past itself.

Electric Motors. Electric motors may be of various types—namely, those for continuous currents, with which we are principally concerned in this chapter; induction motors, which are more particularly described in the chapter on Three-Phase Alternating Currents; and Single-Phase Repulsion Motors, to which reference is made in the chapter on Electric Railways.

Continuous-current motors may again be divided into two types, distinguished principally by the method in which the field-magnets are wound. Series-wound motors, in which the field-magnets have a thick wire winding carrying the whole of the armature current, have special characteristics, which are fully dealt with in the chapter on Electric Tramways, as they are very useful for that purpose. Shunt-wound and compound-wound motors are most common in industrial work, and claim our special attention in this chapter.

Shunt-wound Motors. These motors have a fine wire field-magnet winding connected in parallel with the armature circuit (as described in the chapter on the Dynamo), so that only about 3 to 5 per cent. of the total current passes through it. When supplied from constant-pressure circuits—the usual condition of public supply—shunt motors work at nearly constant speed, whatever the load. If absolutely constant speed is necessary, it is easy to arrange this by making the motor compound-wound; that is, having a few series turns in addition to the shunt winding. The series coils must, however, weaken the shunt field, and not strengthen it, as in the case of a compound-wound dynamo. (See p. 1152.)

The Propelling Drag on a Motor. To understand the action of a motor, it is well to remember the character of the drag which a magnetic field exerts on an electrical conductor carrying a current. This is shown graphically in **94**. This represents the pole of one of the electro-magnets, a north pole of nearly square shape, with its invisible magnetic lines radiating out of it. In front of this pole there lies a copper conductor carrying an electric current, which is represented as flowing from us along the wire. Then it is experimentally found that this wire is acted on by a force which is neither an attraction toward the pole nor a repulsion from it, but a mechanical drag tending to shift the wire sideways to itself, and upward past the whole. If the pole were a south pole instead of a north pole, the drag on the current coming toward us would be downward instead of upward. If the pole were still a north pole, but the current had been reversed in direction so as to flow toward us instead of from us, then the drag would be downward. Reversing the sense of either of the two elements (the magnetic field or the current) reverses the direction of the mechanical force. But if both were reversed at once the mechanical force would still be upward.



94. MAGNETIC DRAG ON CONDUCTOR CARRYING CURRENT

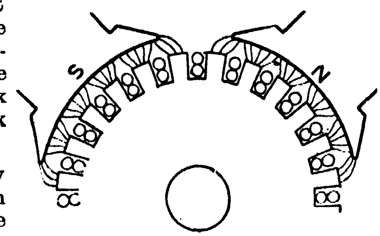
Calculation of Force on a Conductor. The formula for calculating the amount of force acting in such a case is this. Let the symbol B stand for the flux-density—that is, the number of lines per square inch at the pole surface; C_1 (or I_1) for the current (amperes) carried by one wire; l, the length of wire crossing the flux, being the same as the length across the pole face; then the force f, in pounds, with which the wire is urged across the pole, is given by the rule:

$$f = B \times C_1 \times l \div 11{,}303{,}000.$$

For example, if $B = 45{,}000$ lines per square inch, $C_1 = 10$ amperes, and $l = 5$ in., then $f = 45{,}000 \times 10 \times 5 \div 11{,}303{,}000 = 0{\cdot}199$ lb.

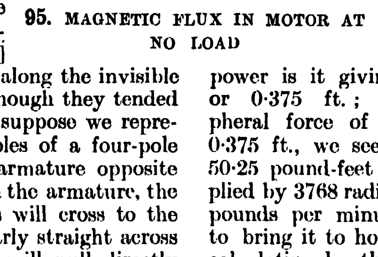
In some old patterns of motors the armatures had smooth iron cores, with the copper windings lying on the outside of them, bound on by binding wires. In such cases the copper wires were dragged by the action of the magnetic field, and this drove the motor. For instance, if in some such motor the drag on each wire had been, as calculated above, about one-fifth of a pound, and if there had been 400 such wires passing under the various poles, the

total peripheral drag tending to turn the armature would have been equal to 80 lb. But in modern motors the armature cores are always built up of toothed core-discs, and the copper wires (properly insulated) are wound in the slots between the teeth. In that case, the propelling drag does not come upon the copper wires, but comes upon the iron teeth, and drags them round. The amount of the force is just the same as if it came on the wires, but the mechanical construction is far better, as the wires are protected from risk of displacement by being sunk in the slots.



95. MAGNETIC FLUX IN MOTOR AT NO LOAD

Magnetic Drag. We may regard the propelling drag in the motor as the result of the magnetic reactions between the field-magnet poles and the armature. We know [see page 493] that there is always a tension along the invisible magnetic lines, which act as though they tended to shorten themselves. Now, suppose we represent, as in **95**, two of the poles of a four-pole motor and the piece of the armature opposite them. If there is no current in the armature, the magnetic lines from the poles will cross to the iron teeth of the armature nearly straight across the clearance, and each pole will pull directly at the teeth opposite, and this pull will not tend to drive the armature either way. But if, as in **96**, the armature wires are carrying currents (the dots and crosses represent currents coming toward or from us, as explained on page 1149), then the magnetic lines will be distorted, as shown, and will cross the gaps obliquely to the teeth; and in that case there will obviously be forces tending to drive the armature and make it turn.



96. MAGNETIC FLUX IN MOTOR WHEN LOADED

Torque, or Turning Moment. The mechanical tendency to turn anything around an axis of rotation is called by engineers *the torque*. It is also called the *turning moment*, or *angular force*, or *couple*. The torque, or turning moment, due to any force is equal to the product of the force and its leverage. Thus, if a force of ten pounds acts with a leverage of two feet, there is a torque, or turning moment, of 20 *pound-feet*. The name of one *pound-foot* is given to that amount of torque which is exerted by a force of one pound acting at a radius of one foot.

Those not familiar with precise scientific terms must not confuse between one pound-foot of torque and one foot-pound of work; for the pound-foot which is a turning effort is the product of a force exerted tangentially, into a length at right angles to it—that is, radially; whereas the foot-pound which is the work done in a movement is the product of a force into a length in the same direction as itself.

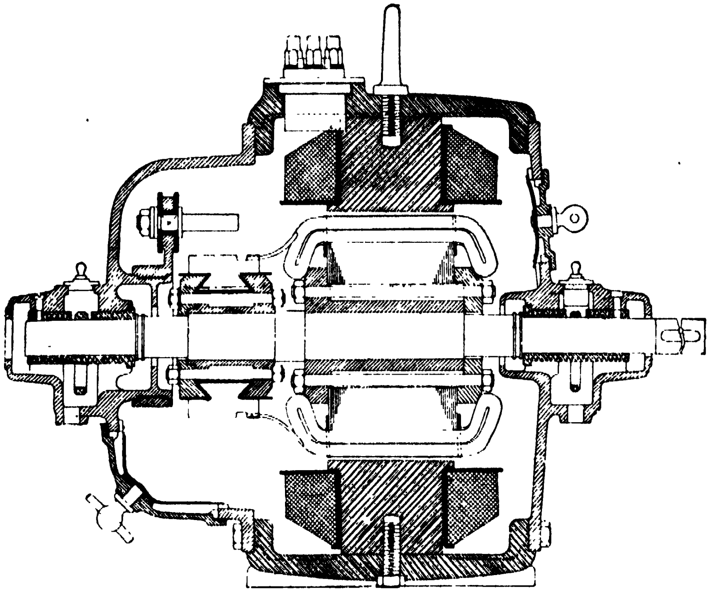
Speed, Torque, and Power. Power, being a product of effort and speed, expressible in foot-pounds per minute, may be stated in two ways: either (1) as product of torque and angular speed, or (2) as product of peripheral force and surface speed. By angular speed is meant the number of *radians* (see GEOMETRY) per minute, and is calculated by multiplying the number of revolutions per minute by 2π (=6·28). Thus, a body revolving at 600 revolutions per minute has an angular speed of 6·28 × 600 =3768 radians per second. We may take as an example of both ways of calculating power the case of a motor armature nine inches in diameter, having a total peripheral force of 134 lb., and revolving at 600 revolutions per minute. How much power is it giving out? The radius is 4½ in., or 0·375 ft.; then, multiplying the peripheral force of 134 lb. by the leverage of 0·375 ft., we see that the torque is just over 50·25 pound-feet; and 50·25 pound-feet multiplied by 3768 radians per minute = 189,342 foot-pounds per minute, which, divided by 33,000 to bring it to horse-power, gives 5·74 h.p. Or, calculating by the second method, the surface-speed will be equal to revolutions per minute (= 600) multiplied by circumference (= 0·75 × 3·14 = 2·355 ft.), and is therefore 600 × 2·355 = 1413 ft. per minute; and, multiplying this by the peripheral force of 134 lb., gives as the power 1413 × 134 = 189,342 foot-pounds per minute, or 5·74 h.-p. as before.

A Modern Motor. Let us study a modern motor, such as is depicted in **97** and **98**, capable of giving out, when tested by a brake, 5 h.p., when running at 600 revolutions per minute, and so wound as to be suitable to work on mains supplied at 220 volts.

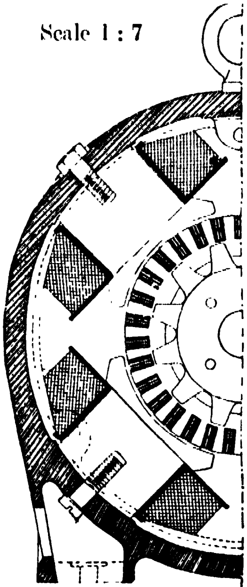
Now, we know that if it is to give out actually 5 h.p. it must actually receive more than the equivalent electrically, because of the inevitable losses due to friction, armature heating, and the like. If we estimate these losses at, say, 15 per cent., the motor must receive from the mains the equivalent of 5·75 h.p.—that is, 5·75 × 746 = 4289·5 watts. Now, dividing the watts by the volts gives the amperes; or 4289·5 ÷ 220 = 19·5 amperes, which will be the current the motor will take from the mains.

The construction of this motor is as follows. There are four poles, each having a flux of about 1,180,000 magnetic lines; and as the surface of each pole is about 26 sq. in., the flux density at the pole-face is about 45,000 lines per square inch. The armature core is built of toothed core-discs, like **63** [page 1009], 9 in. in diameter to a length of about 5 in. They

have 31 slots, 1 in. deep. The armature coils are former-wound, like **61** [page 1008], 15 wires being taped together in each coil, and the coils assembled two-deep in the slots, as in **99**, so that each slot carries 30 wires. The coils, bent



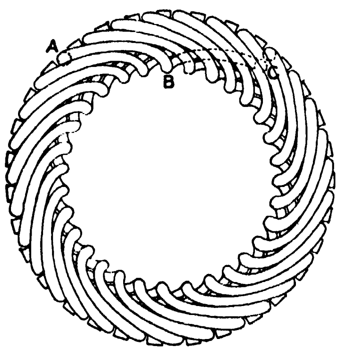
97. MOTOR OF 5-HORSE POWER (LONGITUDINAL SECTION)



98. (TRANVERSE SECTION)

like the one marked ABC, are fitted in symmetrically, and fixed by wedges and binding wire. This makes the total number of wires around the armature 930, of which not more than about 670 are at any one time actually passing under the poles. The grouping of the coils constitutes, as explained on page 1151, a series-parallel winding with two circuits through the armature, like **74** [page 1151]. At full load, each wire, therefore, carried 19·5 ÷ 2 = 9·75, or nearly 10 amperes. The drag on the armature may be calculated as though it came on the wires, and, according to the rule laid down above, will be 45,000 × 10 × 5 ÷ 11,303,000 = 0·199 lb. per wire, or about 6 lb. per tooth under the poles, or in total about 0·199 × 670 = 134 lb. The commutator has 93 segments, and is eight inches in diameter. The field-magnet coils consist of 1200 turns each of a fine wire carrying about one ampere.

Fig. **65** [p. 1009] shows a view of an armature of such a motor when completed, and **101** gives an external view of the whole machine. Small motors under 5 h.p. are often made bipolar, with field-magnets like **51** or **52** [page 1007].



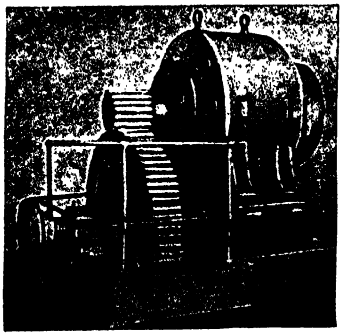
99. ARMATURE WINDING, END VIEW

Motors of large size often have "interpoles," or auxiliary poles. These give a larger output for a given carcase; they will withstand heavier loading without excessive sparking, and they permit wider speed variations. The appearance of such a motor is shown in **106**.

Protected and Enclosed Motors. Sometimes motors are left entirely *open*, and then they resemble the four-pole dynamos depicted in **50** [page 1007]. More often now they are built with end-shields which support the bearings, and thus protect the armature ends, the commutator, and the brushes, such forms being described as *protected* motors. Others are *enclosed* by having the spaces in the end-shields covered with perforated metal; while others, again, are *totally enclosed*, to enable them to be used in factories where an explosive gas or combustible dust is present in the air. As enclosing a motor prevents the cooling of the internal parts by access of air, they have to be given a lower rating; thus, a motor which, if open or only protected, was rated at 5 h.p., could only be rated at 3 or 3½ h.p. if totally enclosed.

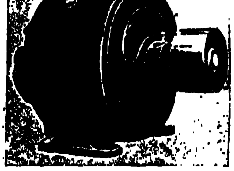
Voltage and Speed of a Motor. There is a fixed relation between the voltage applied to a motor and the speed at which it runs, provided the magnetism of its poles remains constant. For if we regard the revolving armature, as on page 1418, as acting like that of a dynamo, we may calculate what voltage its conductors will create by cutting the magnetic lines. Every motor does this, and necessarily creates a back-voltage, which can, however, never be greater than that which is applied to its armature. In fact, every motor tends to run up to such a speed that

it generates a back-voltage equal to that part of the actual voltage that is applied to its armature. If a resistance be introduced into the armature leads, this will, of course, reduce the amount of voltage that is available at the armature, and reduce the speed. By the rule on page 1152, this motor, with a flux of 1,180,000 lines per pole, 930 conductors, 4 poles, 2 circuits, and a speed of 600 revolutions per minute, will generate a back-voltage of $\frac{4}{2} \times \frac{600}{60} \times 930 \times 1{,}180{,}000 \div 100{,}000{,}000 = 220$ volts, equal, when the motor is running light, at top speed, to the voltage of supply. If load is put on, the speed will drop a little, the back-voltage will drop correspondingly, and therefore automatically, and more current will flow from the mains to drive the load. At full load with this motor the speed drops to about 570 revolutions per minute, so that the back-voltage drops to about 210 volts. *By weakening the magnetism of the field-magnets of the motor, it will run faster; by strengthening it, the motor will run slower.* This property is made use of to regulate the speed.



100. SPEED-REDUCING GEAR FITTED TO MOTOR

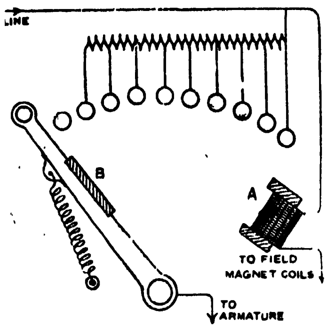
Starting of Motors. Except in the case of small motors, it is necessary to introduce resistance into the armature circuit when starting. Unless this is done, there will be such a rush of current through the armature that there would be a risk of it being seriously damaged. The cause of this is that until the motor attains a reasonable speed there is little or no back-pressure to prevent a rush of current. Consequently motor-starters have been designed which provide for resistance being introduced into the armature circuit on starting. In these appliances, by the movement of a handle, the starting resistance is gradually cut out of circuit as the motor gains in speed.



101. COMPLETE MOTOR OF 5-HORSE POWER

Fig. 102 represents in diagram form a *starter* in common use. The current on its way to the magnet windings is taken round the coils of a small electromagnet at A, so that when the switch arm is moved to the full "on" position, it is held there, against a spring, by attracting the soft iron armature B. Should the current fail to pass through the exciting circuit of the field-magnet by any break of the connections, the electromagnet A at once releases its hold, and the spring pulls the lever back to the "off" position, thus protecting the armature from any abnormal rush of current which might burn it out.

Sometimes motors are fitted with an overload release which automatically releases the controlling lever if the motor, by getting jammed, takes an excessive current from the mains.



102. DIAGRAM OF MOTOR STARTER

Fig. 107 shows a modern motor control pillar as used in the best class of work. The resistance is not only suitable for use at starting, but, as it may remain afterwards in the circuit, it will also serve to some extent for regulating the speed. This resistance, fitted with its no-load and overload automatic releases, is seen in the lower part of the case. Above is the main double-pole switch, and the fuse; and, higher still, the hand-wheel which gives a further control by varying the resistance in the field-magnet circuit. The instrument at the top is an amperemeter (calibrated sometimes in amperes and sometimes in horse-power) for showing the work that is being done.

103. MOTOR DRIVING HOIST

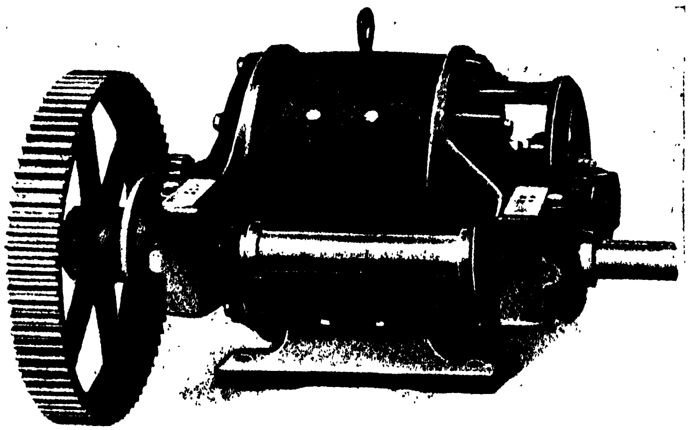
Variable Speeding of Motors. To enable a motor to operate at different speeds there are different devices. One of these is to introduce into the main path of the armature current

more or less resistance. This reduces the voltage that is available at the brushes, and therefore, other things being the same, reduces the speed at which it tends to run. But this device is not economical, as it wastes energy in heating the resistance. In the case of shunt motors—that is, those having their field-magnets excited in shunt circuit from the mains—it is usual to introduce a variable resistance into this shunt circuit, whereby the amount of exciting current, and therefore the amount of magnetism, can be reduced to raise the speed, or increased to lower the speed. This is an economical method, and is often combined with the former plan.

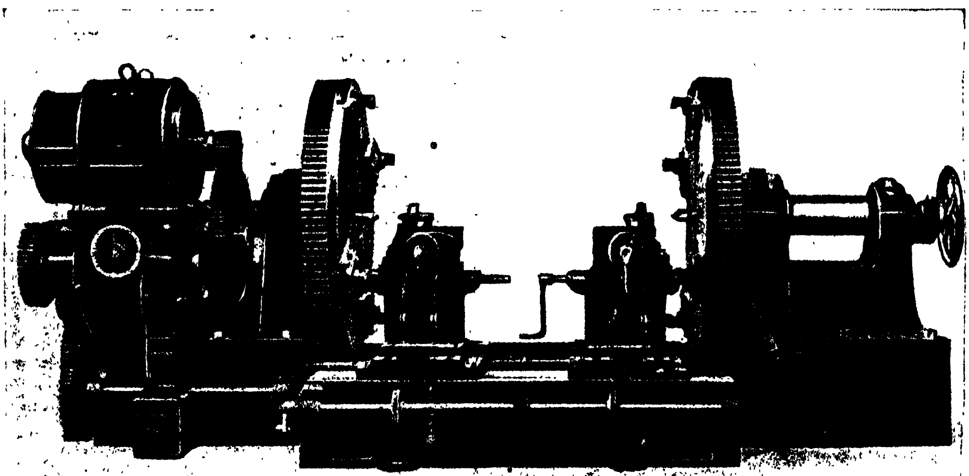
In the case of ordinary shunt motors it is possible, by the combination of these methods, to get a range of variation of speed of 4 to 1, or even of 6 to 1 if the motors are designed with interpoles, but it is necessary to remember that at these low speeds the output of the motor is correspondingly reduced. In the case of series-motors there is another possible means of regulation—namely, by arranging a shunt to the series field-magnet winding, thus weakening the magnet when it is desired to make the armature run faster.

Motor Gearing. It is often necessary to reduce the speed of a motor [100] in order to use a cheap high-speed machine for some work needing low speed. This is effected by the use of gearing [104], as, for instance, in the case where a motor is arranged to drive a large lathe. Figure 103, illustrating a motor driving a hoist, shows the familiar case of leather belt-drive.

Motor Equipments. Motors have now come into such universal use that even short descriptions of their arrangements are not possible here. In the printing world they are very popular. Here a motor must be able to keep a large machine working at nearly full speed when printing off, but during the period of plating it must run so slowly as to move the press inch by inch at will. For some classes of work motors must run at constant speed whatever the load; for other work they must be able to be operated at various speeds at will. Sometimes the motors are placed in inaccessible places, because room cannot be spared for them on the floor of the workshop. Whatever the conditions, the electric motor is found in practice to be equal to the demand upon it, and in almost every instance its reliability and adaptibility have commended it to its owners.



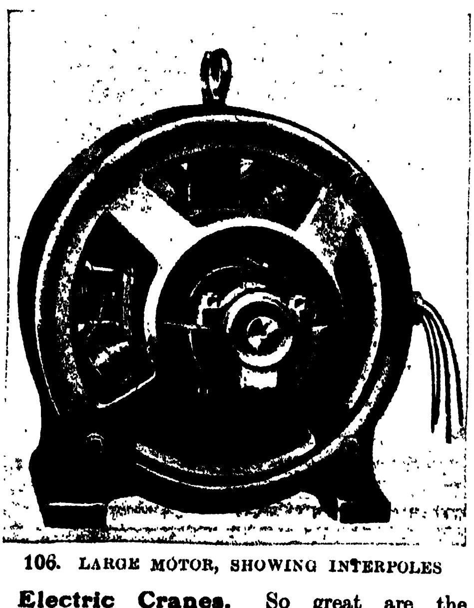
104. BACK-GEARED MOTOR



105. MOTOR DRIVING MACHINE TOOLS

Methods of Driving. The question how to apply the electric drive in particular cases is a very interesting one. It will be evident that

where a large motor is used to drive a number of separate tools, the adoption of long lines of countershafting is the cheapest arrangement in first cost. There is then only one motor in addition to the belting and shafting. Such a combination does not, however, work under the most economical conditions. At times, when only one or two tools are actually in use, the motor as well as the countershafting will have to run, and the cost of the power thus used will be out of all proportion to that needed to perform the actual useful work. The ideal method is to have a motor for every tool. It is expensive in first cost, but each tool is worked under its best conditions at a minimum total expenditure of power. In practice it is necessary to compromise, and the skill of the engineer is shown in the grouping of those tools which work together, so that the working costs are low, while the first cost in the number of motors required is not excessive. In textile mills this group division is very noticeable and very important. It permits the even drive of the motor to be so transmitted to the machines that they may be safely run at higher average speeds than are permissible with other methods of driving; and this results in a correspondingly increased output. In the case of large machine tools the individual drive is almost universal. Figure 105 is a case in point. Here the motor can be started, regulated, or stopped, as required, without interfering with other tools, and the lathe can always be worked under the best conditions. Moreover, the greater the number of separately driven tools, the less the amount of shafting needed. Few persons realise what large amounts of power are wasted in the lengths of shafting turning round, often idly, during the whole time that the works are open.



106. LARGE MOTOR, SHOWING INTERPOLES

Electric Cranes. So great are the advantages of the electric motor as applied to travelling cranes that practically all travelling cranes now made for factories are driven by electric motors. Cranes for shipyards, docks, and railway loading are often now electrically driven. Motors for electric cranes are not required to run at a uniform speed; and as they are used intermittently, with periods of rest in between, it is usual to allow them to be designed with thinner copper conductors and smaller cross-sections of iron than are considered permissible in other motors. As a consequence they heat up more quickly when the current is switched on, but they have time to cool down again.

107. MOTOR CONTROL PILLAR

Power Needed for Working. It is a good plan, whenever possible, to place an amperemeter in the circuit of each motor, or, if a number of motors are used, to have a portable instrument which can be placed in each motor circuit as desired. The readings should be recorded and compared from time to time, so that any sudden increase may be discovered, and the cause found out and remedied. As already stated, the horse-power can be arrived at by multiplying together the amperes and the volts, and dividing the watts thus obtained by 746. If the result is to be expressed in kilowatts, divide the watts by 1000.

Cost of Power. To enable electricity to compete successfully with other forms of power under normal conditions, the prices paid per Board of Trade *unit* should not exceed 1d., or at most 1¼d. At these rates electricity can usually hold its own on the score of cost alone, for whereas with other forms of power the machinery has to be kept running all the time, with an electric motor which can be started and stopped as needed there is no power being paid for which is not actually used. This has a very important bearing on cost in those places where a few machines are wanted at times when the greater part of the work is stopped. Fortunately, in many places electric power is much cheaper than the figure above named, ¾d. and in some cases ½d. per unit being the prices asked for power for motors that run a large number of hours per week. Wherever this is the case—such as in the Tyne or the West Ham districts—a great impetus has been given to manufacturing work. In general, cheap electrical power is proving itself to be a great factor in industrial progress.

SILVANUS P. THOMPSON

Rotary Adjustment. Bent and Flat Finger Attitudes. Toneless Exercise. Wrist Movements. Scale Playing

POSITION OF THE HANDS

WE have dealt chiefly with the *condition* of fingers and hand, and little with the secondary consideration of position; but an interesting question of position arises out of this rotary condition. When the little finger bears up against the forearm rotation its knuckle is brought well up to the level of the hand, or may even be higher than that of the index finger. The position of the back of the hand is consequently level, and even forms a slight slope from the fifth-finger knuckle downwards towards the thumb. The opposite state of affairs is a common fault with beginners; they are apt to let the back of the hand slope very much down towards the outside. But let us beware of trusting too much to appearances; right positions are to be secured, and it is not enough that the hand should *look* like that of a successful player. We may have the appearance of effective "rotary adjustment" without the reality.

The use of the rotary adjustment does not apply merely to the fifth-finger side of the hand; it is employed constantly to equalise (or non-equalise, when necessary) any fingers to make notes—melodies, for instance—stand out at either end of the hand. As this rotary adjustment may help, so it may hinder, when applied in the wrong direction. Be careful not to allow any rotary action of the forearm to keep energy *away from* the side of the hand where it is required.

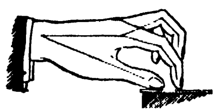
Finger Lifting. We have seen that the finger must make careful contact with the key, or rest on it, before moving it, but it need not be cramped by being glued to the key, as it were, all the time. It may be swung up a little, provided always that when it renews contact with the key it judges its resistance before and during key depression. This judging can be done so quickly that it seems like a continuous movement.

The key moves such a small distance (only ½ in.) that the fingers are apt to get cramped by such slight movement; hence, it is customary to advise—most teachers, indeed, specially insist upon—an upward movement of the fingers, when there is time for it, before taking hold of the key to move it. Such movement is not essential to tone production, but is healthy for the muscles. It makes for freedom of action, and enables us better to "think the fingers," provided that there is no stiffness in the upward movement or following down movement, and provided that we do not allow our attention to be distracted from the following finger descent. All such movements *towards* the keys, indeed, whether of finger, hand, or arm, should be rather passive than active.

Bent and Flat Finger Attitudes. For brilliant, clean-cut tone, if we play the keys from a little distance, the fingers should be bent, as shown in this diagram.

For sympathetic, clinging tone, the fingers in moving towards the key should be left rather straighter, as in the lower of these two diagrams.

These two contrasted "finger attitudes" are not only both legitimate, but are essential to truly artistic, varied, contrasted technique, and we must practise both forms. In using the "bent finger," the nail-joint moves up and down in a straight line vertically with the keys, thus:



and brings the very tip of the finger (close to the nail) in contact with the key. In "flat finger" the nail-joint moves obliquely to the key, and brings the soft cushion (opposite to the nail) into key-contact. The chief difference to the *eye* is that, when the finger is well raised as a preliminary, it starts very much curved in the "bent," and fully opened out in the "flat," attitude. The "bent" requires the knuckle sufficiently high to take the thrust, the "flat" admits a very low or very high wrist.

Arm-weight Tendencies. The bent-finger attitude may be called the "thrusting" attitude, the flat-finger attitude the "clinging" one. With the bent finger the weight of the arm tends slightly *forward*; this should be only an inward muscular tendency, there is no outward visible movement, and in brilliant finger work we should never forget this "forward tending" arm—it makes one's playing feel as easy as running downhill. With the flat finger, on the contrary, "the arm tends to fall backward," but we must be careful not to *pull* the elbow backward instead.

Bent and Flat Finger Touches. The "forward" bent-finger playing favours sudden key-movement, which induces brilliant, short tone; the "clinging" flat-finger attitude, with its backward tending arm, favours gradual key-movement, which induces sympathetic singing tone.

"The anticipated fall of the upper arm causes one to use the finger in the clinging or 'grabbing' way, while the consciousness of the forward sustained elbow causes one to use the fingers in a kind of stamping or thrusting action." [Matthay] For brilliant work, then, see to it that we sustain the weight of the elbow forward, and that for beautiful singing tone we allow it rather to tend to lapse backward.

It is this flat-finger clinging attitude that we must use in playing a great deal of Chopin's

music. Chopin himself often used this form of technique, and consequently pianists who may have been drilled entirely in the bent-finger school do not succeed in playing the master unless they either forget the tyranny of their method or ignore it.

Faulty Technique. We must consider all these things even at this early stage, although we may not be able to realise them till much later in our study. If we are not getting along easily with quick, brilliant passages, for example, it is either because we are key-bed squeezing, or because we are opposing the acting muscles by the sympathetic activity of the opposite set of muscles, which ought to remain passive, thus setting up obstacles to successful and easy playing *within our own hand and arm;* or, again, because we are trying to play a brilliant passage with a backward hanging arm, instead of keeping all the weight well forward, which would cause the fingers to feel as though they were running downhill.

On the other hand, when trying to play a long-drawn-out melody we shall fail unless we let the whole arm relax before and while we move the key, and let the "clinging" attitude (with flatter finger) feel as though, "in climbing a stair, the hand, gently resting on the banister, helped to pull us upstairs."

Finger-condition Test. We have had a toneless exercise at the keyboard for daily testing the relaxed condition of the "up" muscles of the hand; here is one for testing the same with regard to the fingers. Rest on the keys as before, without depressing them, and, with a forward movement of forearm, push the hand gently towards the black keys (the wrist here moves on one plane, and does not, as in the former example, rise and fall), rolling the fingers up and, as it were, passing them by. This forms the second part of the first of Matthay's three chief muscular tests.

If the "up" muscles of the fingers are relaxed, the tips will remain in their places, while all the joints will give way, and allow the fingers to be rolled up into an exaggerated bend on the keys, as though they were about to take the shape of a closed fist. The gentle resting weight must be felt continuously on the keys. If the "up" muscles were not relaxed, the fingers would "lock" the knuckles of their little joints, as the hand can lock its big knuckle, which we call the wrist. In such a locked condition the finger-tips would slide to and fro on the slippery ivories, and be in a totally unfit condition for successful playing. We must be constantly testing them for this. The student should write out these "daily tests" and playing maxims on a card, and keep them before him during practice.

In both of these silent keyboard tests, the finger-tips retain their places on the keys. In the first, the wrist rises and falls; in the second, it moves to and fro towards the ebonies and back again in the one plane.

There are two other "tests" which have to be considered—the test against down-arm force and the tone-aiming test; one *to ensure the arm being used only as a weight reservoir,* so to speak, and the other *for the practice of precise aiming*—aiming of the tone-making spurt, the added impetus that is used between two "restings."

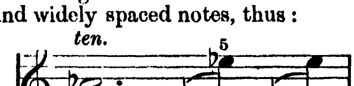
Arm Force Elimination Test. For the first, at the end of a short run or arpeggio we are to let the arm rebound from the keys. If the last note be played *forte e marcato,* the arm will seem to be "kicked off"; if, on the other hand, the final note be soft, the arm will appear to be "floated off." In either case the movement must be of the nature of a rebound, absolutely unwilled and *staccatissimo;* it must not, in its initial stage, be a willed action, "it must *seem* as if the key, in its rebound, impelled the arm upwards."

The next test is an "aiming" exercise. We have seen that finger and hand down muscles are used to bear up against relaxed and loosely left weight of the arm in the third species of touch; and as this weight is to be used only during the short spurts of hammer-driving, and not during the longer or shorter terms of damper-controlling, we must learn so to aim this arm-weight lapse that it shall take place neither too soon nor too late, nor remain in operation too long.

Aiming Test. The "aiming test," then, may take this form. Rest on the keys, say, on an easy chord; see-saw them gently down and up several times (tonelessly); after that, let them move down to tone, and *let them rebound,* the fingers never losing their hold of the keys, and the wrist, which is relaxed at the moment of making the tone, then being dropped below keyboard level.

If the student wishes for a detailed description of all these "muscular tests," which are taken from Matthay's "Act of Touch," reference must be made to the book itself, or to the condensed edition, "First Principles of Pianoforte Playing," or, better still, to his "Relaxation Studies."

We now come to the question of "getting about" over the keyboard—a difficult one, as we have but ten fingers for 88 keys. We have tried only the five-finger position, five fingers on five contiguous ivories. Now let us try to sound widely spaced notes, thus:



Lateral Wrist Movement. To reach them, we must not try to depend upon a stretching of the fingers and hand; we must use also a side to side movement of the wrist to bring each finger in succession over its keys. This lateral movement must be as free and unopposed as the vertical wrist movement.

Resting gently with forefinger on A♭, glide the wrist end of hand and forearm gently to the left. Place the thumb on C, then, after sounding the note, move back again towards the right, continuing the movement till we can easily place the little finger on E♭.

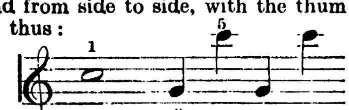
All arpeggio chords must be played thus, and to attempt to do so by merely *stretching* the fingers is apt, in such cases, to defeat its own

object. The hand and arm, with supple lateral wrist movement, must place the fingers on their respective keys.

Preparing a Note. We must remember here, and always, Czerny's advice in his "Letters to a Young Lady," written 100 years ago: "Never attempt to play a note till the finger is over its key." This is called "preparing" a note. But the vital point in "preparation" is not the *position* of finger and hand over the key, but rather the *condition*. If the principle of resting is properly carried out, this preparation of the next note will take place almost automatically. "Each of the keys forming a passage," says Matthay, "must be conceived not as a separate unit, but each key's position must be conceived and found at a *particular distance* from each *preceding key or keys*." The finger being over and even *on* each key, energy must be applied to it *vertically*.

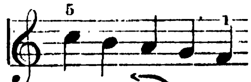
Wrist Movements. We have now been introduced to the three kinds of wrist movement and condition—*viz.*, (1) vertical (up and down) freedom and movement of the joint between hand and forearm; (2) rotary freedom of the same, enabling us to turn hand palm upwards, or vice versâ, and to adjust the rotary weight; and, lastly, this (3) *lateral* freedom—unopposed movement from side to side. There are *no stiff* wrists in normal arms—the stiffness is entirely of our own making. If the wrists prove stiff in any direction, we are using two opposite sets of muscles at once, instead of relaxing one set while the other is at work. "If we always insist on feeling *ready* and *vertical* over each note before attempting its production, we shall fulfil the three conditions of freedom of the wrist —laterally, rotarily, and vertically. While trying for it, we must not be too anxious—mental anxiety often induces muscular rigidity—but we must be attentive. We must watch our sensations, and try to remember and easily recall them when wanted.

The lateral movement can take another form. Instead of pivoting the finger-tip end of hand, and moving the wrist end from side to side, we must also be able to let the wrist end remain motionless while moving the finger-tip end from side to side, with the thumb as a pivot, thus:



The study of these two forms of lateral movement brings us naturally to arpeggio and scale playing.

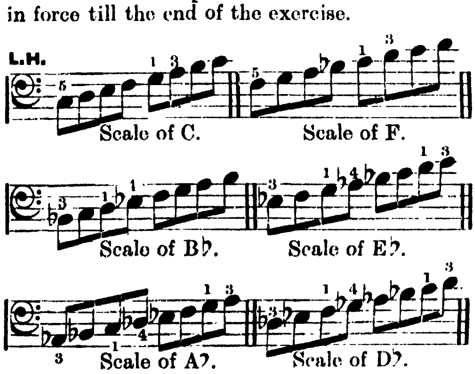
Scale Playing. Let us take our five-finger position thus:



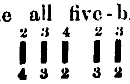
but let the hand lie obliquely over the keys, turned slightly in the direction of the arrow, and when we arrive at the thumb pass the hand laterally over it, till the middle finger lies on E. Then, releasing the thumb from its under-hand pivoting, pass it along the *keys* leftward, preparing thus the two remaining notes, D and C. In scale passages the hand always lies thus slightly obliquely to the keys. "The scale, owing to the required passage of the thumb sideways, demands a slightly *outwardly* turned wrist, or *inwardly* pointing hand and fingers, as the normal position." [Matthay]

Study the scale at first in the manner given here, each hand separately.

N.B.—Each sharp as it is introduced is to be in force till the end of the exercise.



N.B.—Scales of C and F alike; scales of B♭, E♭, A♭, and D♭ alike. Scale of G like all five-black-note scales:



Some Simple Chemical Tests for Textiles.
Methods of Determining Colour-fastness.

TESTING FIBRES AND FABRICS

THE microscope affords the only means of distinguishing finally between fibres of certain sorts, but it is not the only apparatus in use to determine the nature of raw materials or of textile goods. For some purposes chemical tests are preferable to microscopical ones, and for other purposes no apparatus is required at all.

It is scarcely practicable to set down all that may be learned from experience and the use of the senses, although an idea may be given of what is possible to the observant eye and the experienced touch. A fully skilled man, on touching a piece of wool, knows not only that it is wool, and nothing else, but is also able to announce its quality or spinning number at once. Persons engaged, for example, in rag-sorting determine the presence of cotton in woollen fabrics as though by instinct. Rags containing cottons are, for one thing, usually rather harder and colder to the touch. Linen, again, is colder to the hand than cotton, and a hand practised in handling both appreciates the difference instantaneously. Threads of linen are normally more irregular than cotton ones, and the presence of thick places in the woven fabric may betray linen to the eye. Artificial silk proclaims itself different from the natural article both by coldness to the touch and by a metallic lustre foreign to real silk. Spun silk presents visible differences from net silk that are quickly detected.

To Tell Animal from Vegetable Fibre. The comparative method of examination is the most immediately useful of any, but in the nature of things the lessons can only be learnt by contact with the articles themselves, and by the exercise of the powers of observation. The most that can be done by instruction is to give some means of setting at rest doubts as to the identity of fibres. The methods most in use are simple, and the commonest aid of any is a lucifer match.

By watching how a fibre burns it is easy to tell whether the material is of animal or vegetable origin. In dealing with a fabric it is best to detach some threads, and to test both warp threads and weft threads by holding out a short length with one hand, and applying a flame to the end of the thread with the other. If the thread burns freely with a bright, luminous flame which travels along and leaves little ash, the vegetable origin of the fibre can be accepted as a fact. If the flame shows little disposition to travel, if the thread swells and chars, and the ash forms itself into a knob, the material is certainly animal; in other words, it is either wool or silk, and its general characteristics are probably marked enough to determine which of these two it really is. Mistake between wool and silk is improbable, but, of the two, in being burnt, wool gives off the more pungently ammoniacal smell.

The combustion test gives a clear demarcation between threads of all-cotton or all-vegetable fibre, and threads of all-wool, but is not quite so conclusive when animal and vegetable fibres are mixed in the one thread. When a woollen thread —extracted, for example, from the warp of a blanket — tends to burn rather freely, an admixture of cotton in some considerable proportion may be suspected, and a chemical test will set the point beyond dispute. Instead of resorting to chemistry the yarn may be unravelled, and a flame applied to individual fibres in succession will show which of them are vegetable and which are not. Cotton is easier to distinguish in some mixtures than others, and no especial skill or experience is needed to note the difference in the fineness and in the curl of the fibre, or the manner in which the cotton filaments break when their ends are pulled.

Distinguishing Cotton from Wool. Cotton is by very much the most likely vegetable fibre to be found in intermixture with wool, and its identity can always be proved by use of the microscope if absolute certainty is required. In practice, the identity can almost always be assumed, and the point of most importance is to establish the proportion of wool present in the mixed yarn or fabric. The wool constituent can be destroyed by boiling the sample for 15 minutes in a 10 per cent. solution of caustic soda or potash, an operation which is accompanied by an offensive odour, principally of sulphuretted hydrogen. The vegetable part of the mixture remains, and the proportion of wool originally present can be found by comparing the original weight with that of the washed and dried residue. The strong alkali is not entirely without action upon the vegetable fibre, and experiments made at the Philadelphia Textile School show that a correction of about 3 per cent. is needed to allow for loss of weight in the cotton.

The converse test is to destroy the cotton instead of the wool, a thing that is easily done by first saturating the sample in strong sulphuric acid, and then baking it dry at a temperature from 80° to 100° C., until the cotton is reduced to a brown dust. As the acid has a limited action also upon the wool it is advisable to calculate upon a 2½ per cent. loss in its weight.

Acid Test for Wood and Silk. Caustic alkaline solutions are used to distinguish wool from cotton, but acid is employed to separate wool from silk in such fabrics as silk and wool hosiery. Concentrated hydrochloric acid should be used, an acid which has very little effect on wool, although it dissolves mulberry silk almost immediately. Tussah silk, however, is not dissolved by this reagent, and recourse has to be made to other means to isolate this fibre. The

hot caustic solution, which dissolves wool in 15 minutes, dissolves mulberry silk in about 12 minutes, but takes 50 minutes to destroy tussah.

We are not necessarily dependent on chemistry to distinguish between the white or yellow mulberry silk and the coarser, stronger, and harsher brown tussah; but unless the difference in their solubility is noticed some misconception may arise. As it is used mainly for plushes in conjunction with cotton, tussah or wild silk is not generally found intermixed with wool.

Wet Test for Real and Artificial Silk. Confusion is most likely to arise between silk and the artificial silks, but very simple tests serve to distinguish one from the other. Substantially no difference is made to the strength of real silk by giving it a wetting. If a strand of artificial silk is wetted upon the tongue or by other means, and if its strength when wet is compared with that of a similar thread dry, the wetted sample will be found to be weakened materially. We have seen that real silk, when touched with a flame, swells and does not burn. Artificial silk, however, behaves like cotton, and is consumed freely, leaving little ash.

Combustion Test for Weighted Silk. It is frequently desirable to distinguish *weighted* from unweighted silk, as there is a substantial difference in the value of silk pure and of silk increased three or four times in weight by the iron and tin salts applied by the silk-dyer. The experiment is readily made with a match. In burning, threads of weighted silk do not swell freely, and they leave an ash containing metallic salts behind, much the shape and size of the unburnt fibre. The match should be applied again and again to this ash, when it will be found that the metal becomes red-hot, and glows like a length of fine iron wire heated by the same means. The ash can be heated to redness and cooled repeatedly.

How Cotton is Detected. The mercerised cotton, which is sometimes mistaken for silk by reason of its brightness, burns in the same way as non-mercerised cotton, and a test by burning dispenses with the hot caustic soda solution, unless it is necessary to separate the silk and the cotton contained in a mixed fabric.

Microscopy gives the best means of distinguishing between any two vegetable fibres, and in a degree all chemical tests are unreliable, as the cellulose of which the fibres are composed is approximately the same. It is possible, however, to draw certain deductions without the microscope in cases which often present themselves. The question whether a fibre of vegetable origin is cotton or flax may possibly be decided by measurement, as flax fibres attain much greater lengths than any cotton. Another way to decide between them is to dye samples in an alcoholic infusion of cochineal (1 gramme ground cochineal insects in 50 c.c. of alcohol, filtered). This dye turns wool and silk scarlet, and colours linen to a deeper shade of red than cotton, which it dyes only to a pale red or yellow. The test is not quite conclusive in itself, but its result is strong enough to lend assumption some support.

If a sample is dropped into strong, cold sulphuric acid a black mixture will result if the fibre be flax or hemp, whereas cotton will disintegrate gradually without coloration.

In its most familiar form the question becomes one of whether in a given fabric all the threads are linen. Cotton is cheaper than linen, and is thus a possible adulterant, and large numbers of shopkeepers have been fined for selling *union* linen as pure linen. An opinion can be formed by tearing a sample of the fabric. Linen is stronger than cotton, and if the cloth is very perceptibly stronger along one set of threads than along the opposite set, a suspicion that one-half the cloth is cotton is set up. Practised persons recognise a difference between the sound caused in tearing linen sharply and that made in tearing cotton.

Dantzer's and Other Tests for Linen. Linen contains more resinous matter than cotton, and burns with a hotter flame. In Dantzer's test a square sample is cut from the fabric, and threads are detached all round the edges, so that the warp and the weft yarns form a fringe. The fringe is touched with a match, and it is frequently found that, whereas the flame from the linen thread is fierce enough to set fire to the body of the sample, that from the cotton threads is not, and the fire dies out at the edge of the woven cloth. This test is not an absolute one, but it is easy to conduct.

Another simple test is carried out with a blot of ink. Linen is by nature more absorbent than cotton, and a spot of ink upon a pure linen fabric spreads in all directions with approximate equality. A similar drop of ink on a half-linen cloth spreads more in the direction of the linen threads than the cotton ones. The blot forms an oval, with its greatest diameter in the direction of the linen. The results obtained vary somewhat with the capillarity of the cotton yarn, but the superior absorbency of linen is well marked. A little more trouble is required to conduct Frankenstein's test with oil. The sample taken should first be boiled in weak washing-soda to remove finishing materials, and, when dried, spread upon glass and saturated with oil. The cotton threads appear opaque and white when the glass is held between the observer and the light, and the linen threads appear translucent.

Various Fibres. As hemp is used only for rough purposes, necessity to distinguish between it and fine linen does not arise. The fact that for an equal diameter it has about twice the strength of linen affords one clue to its identification in canvases, although the microscope must always be relied on for proof. Ramie is seldom met in woven fabrics, and is more likely to be confused with linen than with cotton. Its greater inflammability is one distinction, and that, with the ease with which a length of yarn may be snapped after a knot has been tied on it, compared with the great strength of the same yarn when tested without a knot, is perhaps the handiest means of forming a first impression which the use of the microscope will either confirm or destroy.

Testing Facilities. The simple tests that can be made without elaborate apparatus may be all that are required for a student's satisfaction, but they cannot be relied on to carry conviction to third parties in the event of a commercial dispute. In such circumstances it is customary to relegate the whole question to independent experts upon whose good judgment reliance can be placed. There are individual chemists and consultants with reputations for this class of investigation, and also public institutions from which certificates of the results of tests may be obtained. The Bradford Conditioning House, owned and worked by the municipality, is one of these, and the Testing House of the Chamber of Commerce, Manchester, is another. Their services are at the disposal of all-comers in return for small fees, and are sought by persons in all parts of the world.

Testing may be distinguished into two stages—elementary and advanced, the former requiring no more than a recognition of the article examined, and the latter a more technical one, demanding greater accuracy and taking account of a larger number of points. The one is useful to all who buy or deal with textiles in any capacity, and the other is a matter principally for technical experts. Some simple tests useful in solving questions of common interest follow.

When Hosiery is Unshrinkable. It is not practicable, without putting the fabric to prolonged tests of soaping, washing, and wearing, to determine whether a piece of hosiery is unshrinkable or not. It is possible, however, to tell by elementary observations whether a wool undergarment has been subjected to the process of chlorination, whereby these garments are made "unshrinkable." In the finishing process of manufacture, the goods are subjected in water to the action of the gas *chlorine*, liberated from bleaching powder by the action of acid. The treatment, if carried on long enough, would destroy the wool, but it is stopped at the stage at which the felting properties of the wool fibre have been undermined by the removal of its minute scales. The process has certain other effects, and a drop of water allowed to fall upon a piece of chlorinated fabric is more quickly absorbed than by unchlorinated wool. Again, the spot of water widens equally in all directions, forming a circle, whereas upon untreated wool it spreads more irregularly as well as more slowly. When the fabric has been wetted, and the two surfaces of it are rubbed together between the finger-tips, a crispness is noticed that is not present in untreated goods. A more characteristic difference is that when a dry chlorinated wool fabric is rubbed against a dry unchlorinated piece of wool cloth electricity is generated. In favourable circumstances electric sparks can be seen, or the presence of smaller charges of electricity can be established by the use of the gold-leaf electroscope.

The Fastness of Colours. The question whether the colour to which a cloth has been dyed is "fast" is one which offers room for misconstruction. The term is used loosely to cover a variety of meanings, including fastness to rubbing, fastness to washing, or to light and other influences. At best the term can only have a relative meaning, and is to be considered in the light of the use to which the fabric is to be put and the time that it can be expected to wear. A higher standard is necessarily demanded in articles like carpets and hangings than in garments that will be soon worn out.

A colour may be said to be fast to rubbing when no tinge is give to a piece of unsized cotton cloth or a piece of suitable white paper. The fabric is laid upon a smooth surface, and scrubbed with the tell-tale white object by hand.

Tests for Fastness to Washing. Fastness to washing is an ambiguous term, unless reference is made to the character of soap used, and to the length and number of the washing operations. A mild test for the fastness of washing colours is to boil the sample for twenty minutes in a 1 per cent. solution of a perfectly neutral soap. A more severe one is to boil the sample for the same time in a soap solution of the same strength, with ½ per cent. of washing-soda added. The sample is twisted and wrung afterwards between white calico, and note is made if the colour *bleeds* or stains the calico cloth. The tests are applicable to coloured cloths intended to be washed, and they may be repeated indefinitely.

Goods like blue wool serges, not made to be washed, but liable to contact with mud and alkalies, are deemed absolutely fast against such enemies if the colour will stand boiling for five minutes in a solution of washing-soda, of a strength of one handful to a quart.

Colours are called fast against perspiration if they are unaffected by successive dips into a solution of about 2 per cent. of acetic acid, the sample being dried, but not rinsed, between the dippings.

Sunlight Test for Fastness. Fastness in these respects is more or less independent of the equally important matter of fastness to sunlight. The conclusive test is exposure to the sun for an appropriate length of time. Manufacturers of high-class woollens and worsteds require that their colours shall stand exposure for a year without serious alteration. Samples of the cloths to be tested are cut and folded. Half the sample is protected from the light by folding it in paper, and the sample is exposed preferably in the open and at a south aspect for one year.

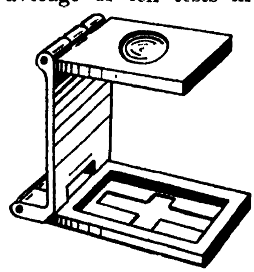
Colours, on the whole, are faster to light when dyed upon wool than upon cotton, and a much shorter time suffices to test light fancy shades than deep colours. Patterns of these are exposed in the manner described, and examined daily. Large dyers have their own means of testing the fading of colours with powerful artificial light, and are able by experience to judge of the permanence of the shade by noting how soon the first sign of fading occurs. No colours are imperishably fast to light, and in goods like carpets the several colours used must all fade in one ratio and to similar extents.

The Strength of Fabrics. Exact tests of the comparative strength of fabrics require the use of apparatus such as is kept in testing laboratories. A sample of standard size is taken and clamped between jaws. Strain is applied by turning a handle until the sample breaks, and the breaking-strain is read upon a dial. In testing the strength of cloth by hand, judgment should be formed not by tearing but by breaking, or endeavouring to break the sample. The correct method is to take hold of the cloth between the thumbs and forefingers of both hands. The fists should be closed, and the test should be made by pressing the thumbs closely together, while drawing apart the two sets of knuckles beneath. The thumbs are laid closely together, and the straining point is immediately between them. The effort should be made in two directions, to test both the warp and the weft threads, and the sample that cannot be broken by these means is regarded as strong enough for the regular purposes of wear in suits. It may be found upon making the test that in some cloths the threads slip away from each other under the strain, and that in some others the pressure causes stretching. In either event, the information is of use in displaying the nature of the fabric, and the steady strain brought gradually to bear by thumb pressure gives a much safer index to strength than tearing motions made with varying suddenness and violence. Tensile strength is not identical with durability, and all-round wearing properties cannot be estimated purely from breaking strains.

The Counting of Threads. A little instrument that is almost indispensable in forming opinions as to the comparative values of similar cloths can be bought for a trifle from any optician. In some catalogues it is described as a *linen prover*, but is known also as a *cloth* or *piece* glass. A magnifying lens is mounted upon a hinged frame of metal, which folds into small compass for carrying in the pocket. The upright of the frame is pierced in order not to exclude light, and the foot of the frame is pierced also with a square or oblong opening. The instruments are made in various sizes, with openings of ¼, ½ or 1 inch. The figure shows an improved type of glass in which all these several distances are combined in the form of a cross. In the cheaper qualities the apertures are by no means absolutely exact in measurement.

The purpose of the glass is to facilitate the counting of the threads present within a given space. The quarter-inch space is used (from motives of convenience) in counting cloths woven with a large number of threads, but a superior degree of accuracy can be had by counting the threads in a full inch. The glasses are of very little use in counting heavily *milled* or felted fabrics in which the thread structure is obscured by the nap or *cover* upon the surface of the cloth. On the other hand, they are invaluable in dealing with goods in which the interlacing of the threads can be seen, and sometimes they give the only ready means of determining which of two samples is the better value at the price. Other things being equal, that sample is best which contains the greater number of threads within a given measurement.

As an error of one thread in a quarter-inch means four threads to the full inch, a systematic procedure should be followed in making the count. The usual method is to count every thread that can be seen through the glass, even if it is impossible to see more than one side of it. In the Manchester Testing House the glass is placed in such a position that the edge of one thread can just be seen, and this is counted as the first thread in the inch. The threads are all counted, and from the total thus found one thread is subtracted. Cloths are counted warp-wise and weft-wise, and immense quantities of cottons are bought and sold in accordance with the reed and pick thus determined. As small differences may exist in different parts of the same piece, the Testing House authorities prefer to take the average of ten tests in each direction, made upon different portions of the cloth. Goods so closely woven as to be uncountable under the glass have perforce to be dissected. The first and last threads within the given distance are marked, and the count is made after the crossing threads have been removed.



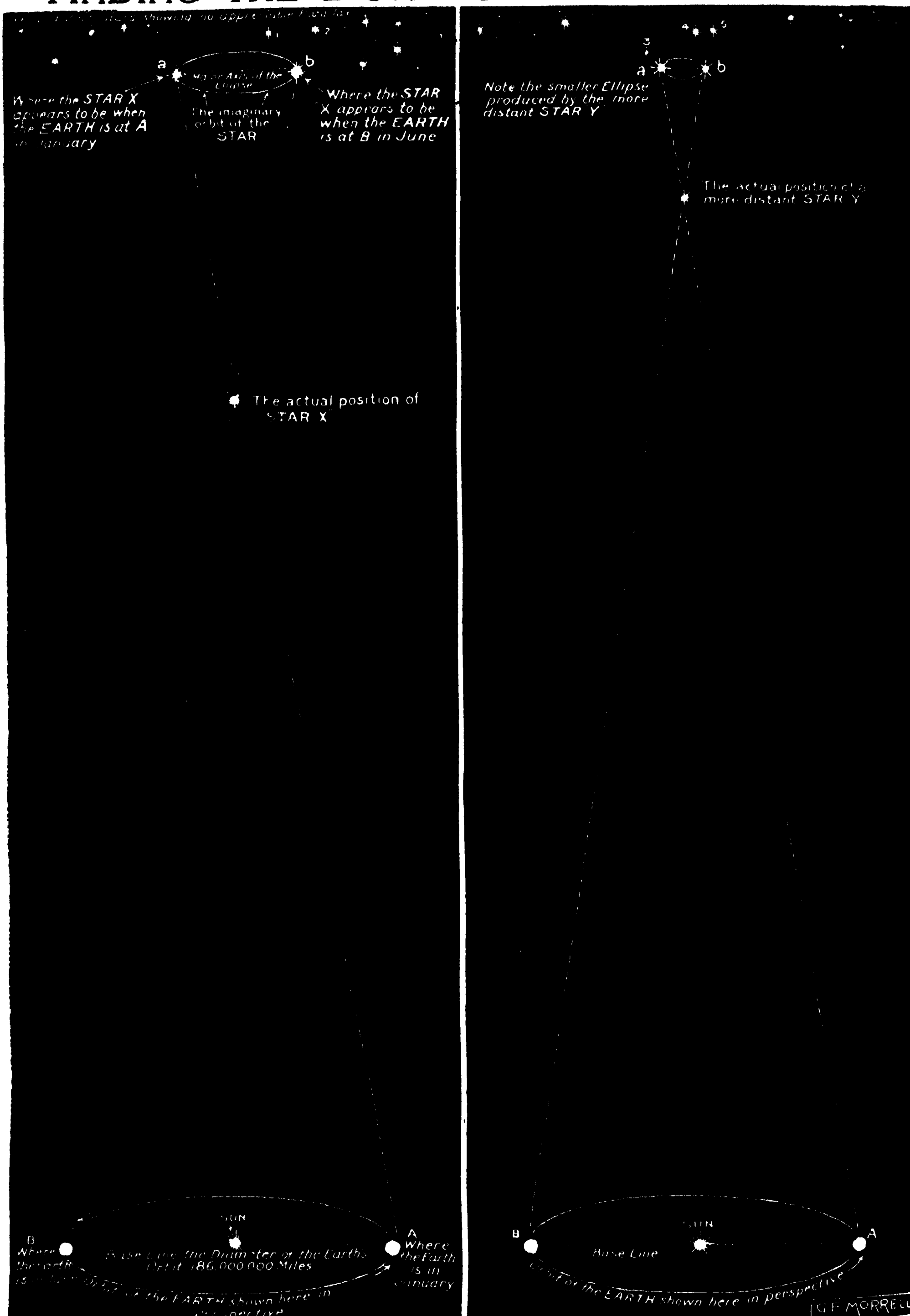
Magnifying glass for counting threads in ¼, ½ and 1 inch.

Test by Weight. Although, of course, cloth is bought ordinarily by the yard, its value is dependent in part upon its weight, and in weighing it is preferable to deal with large samples, unless a chemical balance of proved accuracy is available for weighing small ones. Dies or templates can be bought with which it is possible to punch out a sample one inch square which, weighed upon a balance of sufficient delicacy, will enable the weight per square yard or running yard to be approximated. Granting the perfect accuracy of the die, it is not easy to cut a sample with the high pitch of cleanness desirable when any error will be multiplied more than one thousand-fold in the ultimate result. Moreover, the small sample chosen may vary from the average weight of the bulk.

Given the weight of woven goods and the number of warp and weft threads in an inch, all the materials are present for determining the average *count* of the yarns used in weaving. We have seen that the count of yarn registers the relation of weight to length, and that fine yarns of the same class are more valuable than coarse ones. The two factors, therefore, of threads per inch and ounces per yard need to be considered together in valuing two samples of similar cloth, one against another. When the weight is the same, and the threads in one are more numerous than those in the other, the constituent yarns are necessarily finer. If the difference in quality is made by using more threads of the same fineness, then the truth is necessarily shown up by the comparison of weight.

J. A. HUNTER

FINDING THE DISTANCES OF THE STARS



If we look at one of the nearer stars on January 1, and again on June 30, it appears to have changed its position in relation to more distant stars. This is due to the earth being on opposite sides of its orbit. The greatest apparent displacement of the star thus viewed is called its parallax. In the left-hand diagram the star X, when viewed from the earth in June, appears at b in relation to the more distant stars 1 and 2, which have practically no parallax, but in January it appears at a. The projection which the major axis of the apparent ellipse performed by the star X bears to the diameter of the earth's orbit enables astronomers to calculate the distance of the star. The right-hand diagram shows the smaller parallax resulting from the more distant star Y.

The Magnitude and Motions of Stars
The Journey of Starlight to the Earth

THE FIXED STARS

WE have next to study the nature and constitution of the so-called *fixed stars*. Our sun is a body of the same kind as the stars, of which about 3000 are visible to the naked eye in our hemisphere, and many of which are, in reality, far larger and brighter than our luminary. Yet their vast distances make them appear only sparkling points of light—for no telescope that man is ever likely to make can be expected to reveal the physical features of any of the fixed stars. The spectroscope, however, has told us nearly as much about their chemical construction as about that of the sun, and the telescope and spectroscope, with the gravitational theory, have revealed the most wonderful facts about their movements.

The fixed stars are arranged for convenience in certain groups or constellations, of which about eighty-six are recognised. Most of these constellations date from times when the heroes and totems of early civilisations were placed in the sky by a race living in the Euphrates Valley; many of them were afterwards modified to suit Greek mythology. The particular stars of each constellation are denoted by the Greek letters of the alphabet, Alpha, Beta, Gamma, and so on, beginning with the brightest. Where it is necessary in telescopic work to deal with a great variety of stars, they are given numbers or indicated by their place in some catalogue of stars. The brightest of the stars have also names of their own, like Sirius and Aldebaran.

The stars are classified according to their brightness in a series of *magnitudes*. On the original and rather rough scale, a star of any given magnitude is about two and a half times brighter than the average star of the magnitude immediately below it. There are twenty stars of the first magnitude, which differ greatly in brightness. Sirius is more than fourteen times as bright as Regulus, but both stars are called of the first magnitude. Stars of the sixth magnitude are the faintest normally visible to the naked eye. The more exact photometric methods of modern astronomers have led to more exact classification by tenths, and even hundredths of magnitudes, and in the case of the brightest star a negative magnitude has been introduced; thus Sirius, the most brilliant of the fixed stars, is said to be of magnitude $-1{\cdot}58$. A typical first-magnitude star is Betelgeux, in Orion. The stellar magnitude of the sun on this scale is about -26.

The prime fact about the fixed stars is that they are all situated at gigantic distances from the sun and from one another. For a long time the strongest objection to the theory of Copernicus was that if the earth really changed its place by an annual translation of more than 180,000,000 miles, the stars would have an altogether different appearance in perspective when the earth was at opposite ends of its orbit. The truth is that some of them do look differently to us at intervals of half a year, but the diameter of the earth's orbit is so tiny in comparison with the distance of the nearest star that any change in the apparent configuration of the stars caused by our motion from end to end of it is quite imperceptible to the naked eye, and can only be measured by the most accurate observations with powerful telescopes.

Some of the stars thus display an *annual parallax*, or show a slight difference in direction, according to which end of the earth's orbit we are looking from. The annual parallax of a star is, as already explained, equal to the angle which would be subtended at that star by twice the distance between the earth and the sun. But there is no star in whose case this parallax would amount to as much as a single second of arc. As Miss Clerke puts it, the annual shift of no known star amounts to so much as the width of a sixpence held up at Charing Cross and seen by an observer stationed at Stanhope Gate or Millbank.

The great difficulty of measuring quantities of this nature is obvious. The most delicate instruments and the most refined handling are necessary for tackling the problem. Yet it has been successfully solved in the case of a fair number of stars.

Stellar distances, as will be seen, are so gigantic that we are forced to measure them in terms of some different unit from that ordinarily used in computing distances. The nearest star is 275,000 times as far away as the earth is from the sun. Even this distance, if set forth in miles, would be quite unrealisable. To measure the distance of a star in terms of its parallax, though perfectly convenient for astronomers, has two objections for popular use, because the distance varies inversely as the parallax, and the latter has always to be expressed in small fractions of a second. Consequently, the unit which has been generally adopted for expressing the distances of the fixed stars is that known as the *light-year.* This is the distance over which light would travel in a year.

This distance can be computed in miles by multiplying the number of seconds in a year by the speed of light—namely, 186,330 miles per second. It is more useful to know that the light-year is 63,243 times the mean distance of the earth from the sun, over which light passes in 449 seconds. Thus the light-year is to the distance of the earth from the sun almost exactly as a mile is to an inch. A star with a parallax of one second is at a distance of 3·26 light-years from the earth. To find the distance of any star from its parallax we can use the simple formula $d = \frac{3 \cdot 26}{p}$, where d is the distance in light-years and p is the parallax in seconds. The nearest of all stars is the brightest star of the constellation of the Centaur, Alpha Centauri, which has a parallax of 0·76 seconds, and is consequently at a distance of 4·3 light-years from the sun.

The Scale of the Universe. Let us try to get a rough practical idea of what this means. Suppose we are making a model of the solar system and the stars. Let us start by taking a swan-shot $\frac{1}{8}$ in. in diameter to represent the sun. The earth will be represented by a tiny speck of dust 1 ft. distant from the central globe. The superior planets come at distances varying from 5 ft. in the case of Jupiter to 30 ft. in the case of Neptune, the outermost planet. Some of the periodical planets travel out a good deal farther into space—perhaps as much as 200 ft. or 300 ft. But in order to get the nearest of the fixed stars into our model, we have to travel out for 50 miles before we reach its place on the same scale.

This will give the student some idea of the amazing isolation of our system. There is good reason to suppose that the average distance of the stars from one another is on pretty much the same scale. Some of the most conspicuous and brilliant stars, such as Canopus, Arcturus, and the bright star Rigel in Orion, have yielded no perceptible parallax, which means that their distance can be in no case less than 110 light-years. Among the nearest stars to the earth are Sirius (8·6 light-years), Procyon (10·9), Fomalhaut (23·3), and the Pole Star (44). The determination of stellar parallaxes is one of the most difficult tasks an astronomer can undertake. Photography has greatly helped in it, but there are little more than 163 stars whose parallaxes are well determined. These, however, afford a scale for judging the size of the universe, and it has been estimated that the smallest stars visible in the most powerful modern telescope may some of them be at such a distance that their light would take more than 30,000 years to reach the earth—that is, in the model already described they would have to be placed farther away than the moon.

How History might be Lived Again. We may just remind the reader that this means, among other things, that if such a star were to be destroyed today by some catastrophe its light would continue to shine upon us for 30,000 years, and only at the end of that period would astronomers notice its disappearance. When we look at the star-strewn heavens, we are really gazing not only into the depths of space, but also into the dark backward abysm of time. We see the moon not as it is now, but as it was a little more than a second ago; the brilliant Dog Star shines on us with the radiance which lit it more than eight years before tonight.

Some of the other stars, and those among the brightest, we see not as they are now, but as they were at the time of the Spanish Armada or the Norman Conquest. A French astronomer has made a very interesting and perfectly sound deduction that a disembodied spirit which was able to move instantaneously through space to any distance from the earth, and was also able to see things clearly through any distance, could at will actually see any event which has taken place on the earth since the beginning of its history—at least, in the open air and under a clear sky—by simply travelling out to the distance to which the light-rays carrying the picture of that scene have now advanced.

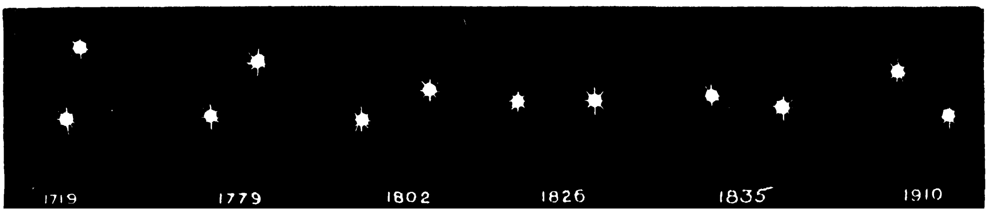
The Real Magnitude of the Stars. Having grasped the conception of the immense distances which separate us from the fixed stars, we are now in a position to see that these stars must in reality be gigantic suns. Wherever we can measure the distance of a bright star, we can make a rough calculation of its size by comparing its light with that given by the sun. We see at once that many stars must in reality be very much larger and brighter than our sun. Sirius, for instance, is at a distance of rather more than eight light-years; if the sun were removed to this distance, it would only give one-thirty-sixth as much light as Sirius gives, and we consequently infer that Sirius is thirty-six times as powerful a light-giver as the sun. There are, of course, two factors in such a result. Sirius may either be very much bigger or very much brighter than the sun. We shall see directly that in many cases we are able to measure not only the brightness but the mass of a star.

Some of the other stars are far larger still. Arcturus, which is about 126 light-years away, must be at least a thousand times as luminous as the sun. Canopus, the second brightest star in the sky—never visible in our latitudes—has shown no parallax at all, wherefore it must be well over 100 light-years away. At that distance our sun would shrink to a star of the tenth

magnitude, absolutely invisible to the naked eye, and it can be calculated that Canopus is equal to at least 22,000 suns lumped together. No doubt many tiny telescopic stars, sunk in infinite space, are really still more brilliant and gigantic stars. Our own sun, in short, must be regarded as quite a second-rate member of the starry host.

The Motions of the Stars. Many stars not only show the annual shift of a fraction of a second which is due to parallax, but also change their position very slightly from year to year in consequence of their *proper motion.* There are two ways in which this motion can be measured. One is by the actual displacement of a star on the celestial sphere. About a hundred stars are now known which thus move a second or more per annum. Such a displacement is perfectly measurable by modern instruments, though it only means that in about 2000 years such a star would move over a distance equal to the diameter of the full moon. The star which has the greatest proper motion yet known moves over about eight seconds in the year. It is, unfortunately, invisible to the naked eye. If foreshortened projection on the imaginary sphere of the heavens. It will be apparent that a star which happens to be travelling straight toward the earth would not seem to be moving at all. But the spectroscope, among its numerous aids to astronomers, enables us to measure a star's motion in the line of sight with remarkable accuracy. This is in virtue of what is known as *Döppler's principle*, which may be briefly explained here.

Measuring Stellar Velocities. We have already seen that the spectroscope breaks up the light given by any star into a series of lines, each of which has a defined place corresponding to the gas which gives birth to it. This is due to the fact that light of any particular wave-length is refracted to a definite extent. But suppose that the luminous object is travelling toward the spectroscope. The result will be that the light which it emits will reach the spectroscope with its own speed plus that of the moving body. Consequently, a greater number of light-waves will reach the prism in a second than would be the case if the luminous object were at rest.



CASTOR, THE BRIGHTEST STAR IN GEMINI, ONE OF THE BEST KNOWN OF DOUBLE STARS

These two stars, easily seen to be double through a small telescope, revolve round each other once in about 950 years. Their relative positions in the last 200 years are shown, scarcely one quarter of their revolution having taken place.

we know the approximate distance of such a star from the earth, we can, of course, calculate its actual velocity.

Runaway Stars. Thus, the extraordinary discovery has been made that the gigantic Arcturus is flying through space with a velocity of 257 miles per second—about 14 times that of the earth. What makes this so extraordinary is that the gravitational theory tells us that a star flying at such a speed cannot possibly be checked by the united gravitation of the whole known universe. It cannot be moving in an orbit, as almost all the heavenly bodies do, but seems to be engaged in a headlong rush through space, traversing the universe as an express train dashes through a wayside station. There are a few other stars of which the same thing has to be said. But, as a rule, the motion of the stars turns out to be similar in kind to that of the earth itself. Where their paths have been noted for a series of years, they generally prove to be not straight, but curved—parts of some vast orbit, which, in many cases, we are able to calculate, as will be shown when we come to speak of double stars. There is a more modern way in which motions of the stars can be measured with even more accuracy. Of course, it is not the case that all the stars which we see moving on the face of the heavens travel at right angles to our line of sight. Their paths lie in all possible directions, and all that we see of them is their

This causes a shift of all the lines in the spectrum through a distance which, though very minute, is capable of being measured with sufficient accuracy to reveal the stellar velocity in question.

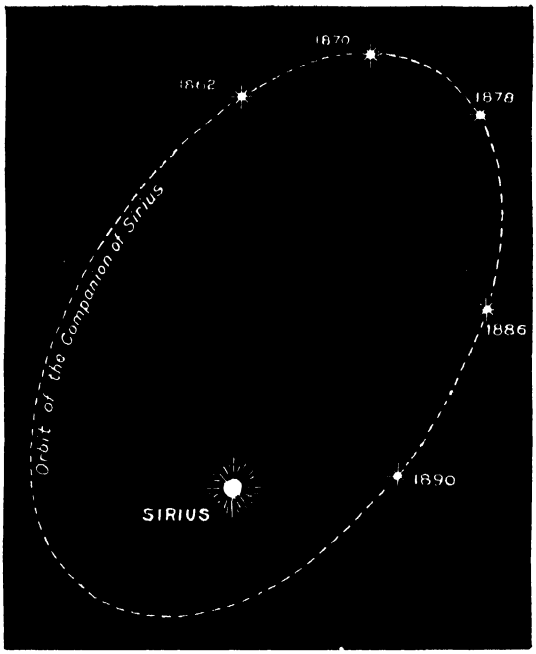
The principle is exactly the same as that by which, when an express train dashes through a station, whistling all the time, the note of its whistle changes in pitch as it passes the observer. When the engine is approaching, a greater number of sounds reach the ear in every second, and the pitch of the whistle seems higher than it would be if the engine were at rest. When the engine has passed, the number of sound impulses in a second is diminished, and the pitch of the whistle drops noticeably. In the same way, the lines in the spectrum of any star shift toward one end or other, according as the star is travelling toward us or from us, and the amount of shift is proportional to the star's velocity in the line of sight. In this way, the speed of many stars toward or from the earth has been measured, and the combination of these two methods of measurement in many cases gives us, by composition, the actual speed and direction of the star's motion.

The chief result of such investigation is to show that there is no such thing as rest in the universe; every star that we can examine is in motion, and this, of course, is perfectly in accordance with the teaching of dynamics, which tells us that no such thing as a state of absolute

rest can exist. All the stars which mutually attract one another are moving in vast orbits, with the exception of the few runaway stars like Arcturus, which seem to have come from the outer void of space and to be hastening back to it again.

Multiple Stars. One of the first discoveries of the telescope was that many of the stars which seem single to the naked eye really consist of two or more, very close together. The first double star discovered was the middle star in the tail of the Great Bear, which shows to great advantage, even in a small telescope. Another very fine double star, easily visible, is Castor, in the Twins. More than 12,000 of such pairs are now known. It is, of course, possible that a pair of stars, apparently so close together that they blend into one to the naked eye, may really be separated by a distance of many light-years, because they happen to lie in the same line of sight but at very different distances from the earth. But by far the greater number of double stars are physically connected pairs, which revolve in an orbit round a common centre of gravity.

Measurements made with the spectroscope show a double shift of the lines, which can only be due to the existence of two stars moving in opposite directions. In many cases this shifting of the lines has been observed to change periodically, so that the actual period in which the two stars complete their orbit can be accurately measured, though neither of them is ever visible separately. As an example of a typical double star, we may take Alpha Centauri, which consists of two stars nearly equal to our sun, which complete a very elliptical orbit about their common centre of gravity in about 81 years. Sirius, again, is the visible member of a double star, and has a companion of half its own mass, but 4000 times less luminous, the pair completing their orbit in about half a century. Not only double stars, but triple, and even higher, combinations exist in the heavens. In many cases these associated suns have strongly contrasting colours, which make them very beautiful objects in the telescope, and must create extraordinary conditions of vision for the possible inhabitants of a planet which happens to circle round one of them. Blue, green, red, and yellow stars are sometimes found, all associated together in a single system.



ORBIT OF THE STAR ACCOMPANYING SIRIUS

This diagram shows the orbit of the companion star as it appears from the earth, and its position in several successive years

Colours of the Stars. Even with the naked eye we can see that the stars vary in colour. Some, like Aldebaran, Antares, and Betelgeux, are fiery red; others, like Vega, near the Pole, shine with a bluish lustre. Others, again, like Sirius, are white with a bluish tinge, but the majority shine with a yellowish-white light like that of our sun. There is good reason to suppose that these different colours indicate a different stage of stellar evolution, the bluish-white stars being the hottest, the red stars being comparatively old and cool, while the yellow stars, like our sun, hold a middle place. Telescopic stars often show much more brilliant colours than any which are visible to the naked eye, shining with sea-green and lilac, gold and azure, orange and emerald. These colours are usually found in compound stars, and not infrequently are observed to vary from time to time.

Variable Stars. A great number of stars shine with a fluctuating or variable light. Observation has divided them into many classes. There are some in which the change is regular and recurrent. The best example of this type is Algol, the Demon Star, which falls from the second to the fourth magnitude once every three days, and is now known to be partially eclipsed by a vast dark satellite which revolves round it in that period. Another type is that of Mira, the Wonderful Star, whose light varies in a cycle of 333 days from below the ninth to nearly the second magnitude. At its weakest, it is quite invisible to the naked eye, while at its maximum it is quite a conspicuous star. Variability of this type is shown to be due to a periodical conflagration in the star. What causes this we do not know, but it is possible that this remarkable behaviour is somewhat analogous to the behaviour of the spots on our own sun, which is itself a very slightly variable star with an eleven-year period. Other stars vary without regularity or warning, such as Eta Carinæ, which is normally invisible to the naked eye, but on several occasions has burst out with a blaze which made it one of the most brilliant stars in the heavens.

W. E. GARRETT FISHER

The Pressure of Liquids, and its Mechanical Application. The Hydraulic Press. Specific Gravity. Buoyancy of Liquids.

HYDROSTATICS

The Two Kinds of Liquids. Matter exists in three forms—solid, liquid, and gaseous. Liquids and gases have no definite shape, and cannot, like solids, resist the action of forces impressed upon them. They are therefore called "fluids." *Hydro-statics* (Gr. *hydro* = water, *statikos* = static, or standing), strictly speaking, deals only with non-elastic fluids—*i.e.*, liquids. Water is so slightly compressible that a pressure of 22 atmospheres (324 lb. per square inch) merely diminishes its volume by a thousandth part. There are widely varying degrees of resistance to change of shape among liquids. Water, chloroform, and alcohol move very freely and are called mobile liquids, but oil, tar, pitch, treacle, and honey move very, very leisurely, and are called viscous liquids. As this, however, is only a question of degree of friction between the particles composing the liquid, and as viscous liquids behave like mobile liquids if they are given sufficient time, this distinction is of little consequence in questions concerning the equilibrium of liquids. A perfect fluid would be one in which friction between the particles was non-existent, and in which there was therefore no resistance to alteration in shape. A moment's consideration would show that as a consequence of this the pressure of a liquid at any point of a surface on which it acts is always perpendicular to that surface at that point. Hence, in constructing embankments, dams, docks, and so on, the pressure of the water has to be considered as acting in the direction of the arrows shown in the three cases in **71**, **72**, and **73**. The pressure is always perpendicular to the surface of the wall, and if the latter be not strong enough, it will be pushed along on its base, overturned, crushed, or lifted, as the various arrows indicate.

How Engineers Use Water. The engineer may be said to regard and to use water in two ways. Pascal, over 200 years ago, investigated the behaviour of water under pressure, and a century later that marvellous inventor, Joseph Bramah, produced his hydrostatic press, the action of which is based on the great law Pascal discovered. The modern hydraulic press, capable of exerting anything up to 12,000 or 14,000 tons pressure, and under whose action steel yields like clay, is an illustration of one of the ways in which engineers use water—by communicating pressure to it in such a way that that pressure, as we shall see later, is enormously magnified. Secondly, water possesses of itself a huge power, due to the force of gravity. Sometimes this is utilised, as in water-wheels and turbines, and in the equivalent form of the accumulator, but just as often it is a force which the engineer is called upon to neutralise, as in the construction of dams, lock gates, and retaining walls.

The Principle of the Hydraulic Press. Pascal, that mystic and fascinating scientist, found that liquids possessed the property of transmitting equally in all directions pressure exerted at any point on their surface. This is well illustrated by the apparatus in **74**. The closed vessel, the shape of which is immaterial, is filled with water, and at different points in its surface are cylindrical openings fitted with pistons. Piston B = twice the area of A; C = three times A; D = four times A. Now, according to the law just stated, any pressure communicated to the water by a piston will be transmitted with undiminished intensity in all directions inside the vessel. If the other pistons had the same area as A, and the latter were pressed inwards with a pressure of 40 lb., B, C, and D would each be forced outwards with a pressure of 40 lb. (in addition, of course, to the pressure previously sustained from the water itself). But as the area of each piston is double that of the preceding one, this 40 lb. pressure at A would become 80 lb. at B, 120 lb. at C, and 160 lb. at D. As the area is multiplied, so is the power. The same law is illustrated in the apparatus known as hydrostatic bellows or hydrostatic paradox [**75**]. AB and CD are circular boards connected by leather bellows; the tube E opens into the interior of the apparatus, and through it water is poured until the bellows are distended as far as it is possible. Heavy weights—even the weight of a man—may be placed on AB, and supported by the weight of the small column in the tube. In this way AB could be made to raise and support a hundredweight if the tube held 1 lb. of water and the area of AB were 112 times that of the tube. It must not be forgotten that this multiplied transmission of pressure is entirely due to the incompressibility of water.

How Hydraulic Presses Work. We are now able to understand the action of that wonderful machine, the hydraulic press, as it is constructed to-day, or, as it is sometimes called, Bramah's press, from the name of the inventor who devised its principle of operation [**81**]. A [**76**] is a force pump which, operated by the lever handle B, pumps water from the chamber C, through the pipe D, into the strong cylinder E, thus forcing upwards the ram F. Let us consider its working in detail. On raising the

handle B, the plunger P is lifted, the valve G at the bottom of the cylinder A is raised, and water enters from the reservoir C. On pressing down the handle B, the valve G closes, and another one (not shown) opens in the pipe D, through which the water is then forced. (An enlarged, detailed view of a pump of this type is shown in **87**.) Imagine this to be continued until the cylinder E is full. When this occurs, we have a state of affairs analagous to that just described in the hydrostatic bellows. The pressure imparted by the plunger P is transmitted undiminished to the piston F, but owing to the greater diameter of F over P this pressure is enormously magnified, and is multiplied in the ratio of the areas of the two cylinders. If the diameter of the plunger P be $\frac{1}{4}$ in., and that of the ram F 10 in., the ratio between their areas will be as 1 : 1,600. Therefore a pressure of 1 lb. on the plunger becomes an upward thrust of 1,600 lb. on the ram. If W = load or weight supported, and P = the load on or force applied to the plunger, then $\frac{W}{P} = \frac{D^2}{d^2}$, D being diameter of ram, and d diameter of pump plunger. From this formula it is clear that the mechanical advantage could be theoretically increased so as to produce an enormous multiplication of force—merely by increasing the ratio of the areas of plunger and ram. But in practice it is found that the strength of the sides of the cylinder necessary to sustain such great pressure places some limit to the power which might be obtained from the application of this law of transmission of pressure.

How Gravity Affects Liquids. Turning now to the pressure water exerts owing to its weight, a very important law runs as follows: *The pressure at any given depth depends directly on the vertical depth below the surface.* This, of course, is self-evident. The liquid may be considered to consist of horizontal layers, those at a great depth sustaining all the layers above. The weight of a cubic foot of water is $62\frac{1}{2}$ lb., and this would be the pressure on an area a foot square at a depth of 1 ft.; at a depth of 2 ft. the pressure would equal $2 \times 62\frac{1}{2}$ or 125 lb.; at 6 ft., $6 \times 62\frac{1}{2}$ or 375 lb.; at D ft., $D \times 62\frac{1}{2}$ lb. If instead of a base of 1 sq. ft. the surface pressed contained A sq. ft., then the total pressure $P = D \times A \times 62\frac{1}{2}$ lb. If the liquid in question be not water, its weight per unit volume (W) would be substituted for $62\frac{1}{2}$, and $P = D \times A \times W$.

Strange as it seems, the pressure of water on the base of a vessel is entirely independent of the *quantity* of water the vessel contains. The pressure on the base of a full decanter would be the same if its sides were vertical or tapered towards the mouth like an inverted funnel instead of bulging, as long as the area of base and depth of liquid remained unchanged. Yet in one case it might hold a quart, in the other a pint.

In measuring the pressure of water against dams, etc., the formula $P = D \times A \times 62\frac{1}{2}$ will not be correct, for, as the pressure varies with the depth, an *oblique* or *vertical* square foot or yard will not have uniform pressure all over its surface; the part nearer the surface sustains less than the deeper parts, and this explains why in cast-iron water reservoirs and tanks, and in foundation caissons, the lower plates are made thicker than the upper ones. It is necessary to take the average pressure, and this is equal to the pressure at the centre of gravity. So the rule for finding the pressure against any surface becomes P = Area of surface pressed × vertical depth of the C.G. of the surface × $62\frac{1}{2}$. Let it be required to find the total pressure against the retaining wall in **77**. Suppose the wall 30 ft. long, and the depth of water (E), 20 ft. The wetted area therefore $= 30 \times 20 = 600$ sq. ft. The vertical depth of the centre of gravity of the surface pressed below the surface of the water is in such a case half the depth of the water, or 10 ft. Hence the total pressure against the wall $= 600 \times 10 \times 62\frac{1}{2}$ lb. = 375,000 lb. = over 167 tons.

Retaining Walls. We have seen in the preceding paragraph how the total water pressure against a retaining wall may be estimated. In calculating the thickness and weight of wall necessary to prevent it being overturned or fractured it is convenient to consider this total water pressure as concentrated at one particular point in the wall, which is called the *centre of pressure.* It is the point at which the resultant of the fluid pressures acts, and these pressures constitute a system of parallel forces with a resultant equal to the total pressure. If an equal and opposite force —*i.e.*, the equilibrant—were applied at this spot, the surface would be kept in equilibrium. A concrete example will render this clearer. Imagine a long, narrow trough or cistern, one of whose ends, instead of being fixed, is free to slide along the length of the trough. If the trough be filled with water the movable end will be forced right out unless it be kept in position by the pressure, say, of the thumb. Now, if the thumb be applied near the top of the surface the water would push out the lower part, and if applied at the bottom, the water would force the upper part outwards. But there is a certain point at which the counterbalancing pressure might be applied, so as to keep the loose end in position and sustain the water pressure. That point is the *centre of pressure.* In the case of a horizontal area the centre of pressure coincides with the centre of gravity, but in the case of a sea-wall, where pressure increases with every unit of depth, it lies below the centre of gravity, and is found to be at two-thirds of the vertical depth below the water surface.

In **77** the pressure P is concentrated at the arrow head, one-third up from the bottom, and it acts in a horizontal direction. P will tend to overthrow the wall by making it turn about B, the moment of the water being P multiplied by BD, the latter in this case being one-third of the depth of the water. The moment of stability of the wall is the product of its weight (concentrated at its centre of gravity G), and the distance AB. If the moment of the wall be

less than the moment of P, the wall will be overturned by the pressure of the water. (Generally, in calculations of this sort, the wall is assumed to be one foot in length, so that the total square feet of area of its vertical section also represents the cubical contents, and when multiplied by the weight of a cubic foot of the material of which the wall is composed, the total weight is obtained.) In actual practice retaining walls are made thicker than the overthrowing moment demands, especially where waves have to be considered. And as regards the form of the wall, although it is found that the stability is greater when the water presses against the sloping side, yet the danger of crushing and fracture often renders it advisable to sacrifice a degree of stability and let the vertical side receive the pressure.

Specific Gravity. Before touching the question of flotation and buoyancy it is necessary to have an exact notion of what is meant by specific gravity. The specific gravity (abbreviated sp. gr.), of any body is its weight, as compared with that of an equal bulk of water, though of course any other substance would serve as a standard of comparison. In the case of gases, air or hydrogen is the standard or unit. Now, as the volume of water or any other kind of matter changes with alteration in temperature, it is necessary that one particular temperature should be decided upon. As water has its greatest density at 4 degrees C. (39·2 deg. F.), that is the temperature generally adopted. Frequently, however, specific gravities are measured at the more convenient temperature of 60 degrees. A cubic centimetre of water at 4 deg. weighs 1 gramme. With this, then, as a unit, the sp. gr. of any substance is its weight in grammes per cubic centimetre. When we say that the sp. gr. of gold is 19·25, copper 8·7, lard ·95, wine ·9, Bath stone 2·1, alcohol ·79, cork ·24, we mean that these figures represent the weight in grammes of a cubic centimetre of these particular substances ; or that the weight, say, of a cubic foot of gold is 19·25 times the weight of a similar volume of water, and that the ratio between the weights of a cubic foot or inch of cork and water is as ·24 is to 1.

The specific gravity of a substance not acted on by water and of greater sp. gr. than water can be found by weighing it first in air, and then in water, and dividing its weight in air by the loss of weight in water. If A = wt. in air, and a = wt. in water, then

$$\text{Sp. gr.} = \frac{A}{A - a}.$$

If a substance weighs 54·3 grammes in air, and 47·8 in water, its

$$\text{Sp. gr.} = \frac{54 \cdot 3}{54 \cdot 3 - 47 \cdot 8} = \frac{54 \cdot 3}{6 \cdot 5} = 8 \cdot 3.$$

If the body floats in water, this method is useless, and a weight called a sinker is attached to the body, which is specifically lighter than water, to make it sink. If A = weight of body in air, B = weight of sinker in air, a = weight of body and sinker in water, b = weight of sinker in water, then the sp. gr. of the body $= \frac{A}{A - a + b}$. Specific gravity may be calculated in several other ways, but by means of an instrument called a hydrometer the sp. gr. of any liquid may be rapidly determined by noting on a graduated scale the depth to which the instrument sinks. With Nicholson's Hydrometer the sp. gr. of either a liquid or a solid may be found.

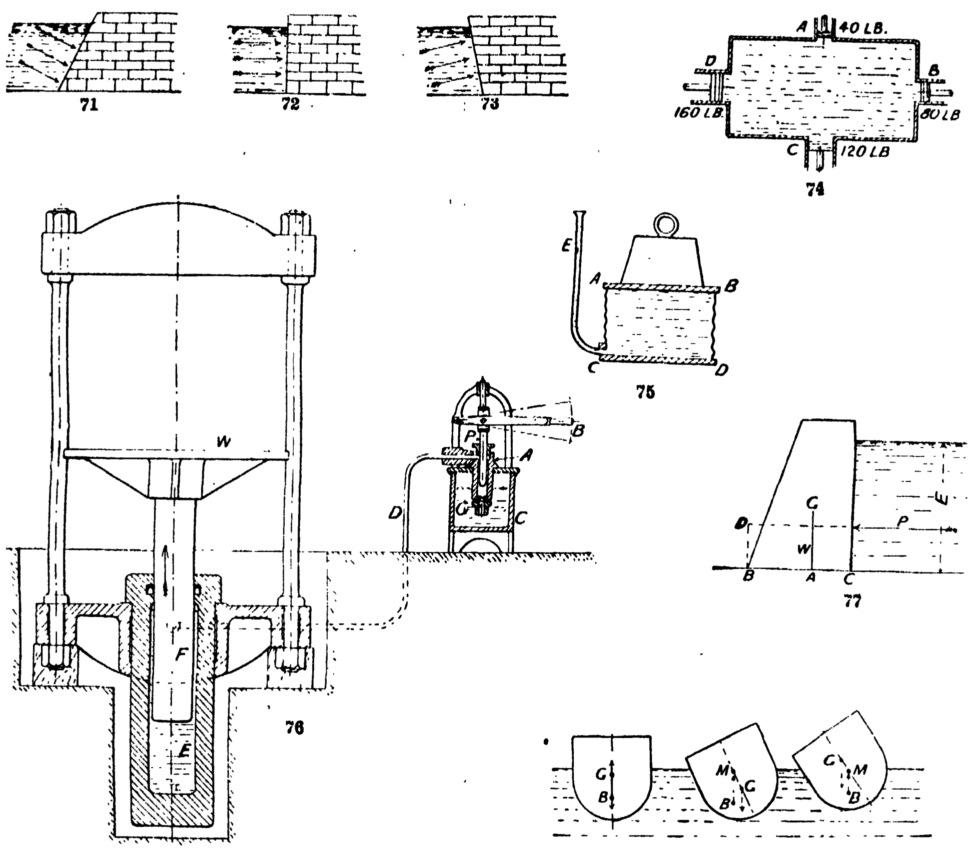
Buoyancy of Liquids. If a man plunges into a river, or a stone be thrown into a pond, a bulk of water is displaced exactly equal to the bulk of the body which enters and is immersed in the water. If it be partly immersed, as in the case of a ship, or a man floating, then the bulk of water displaced equals the bulk of the immersed portion only. That is quite obvious. Whether it be a case of total or partial immersion, two forces act on the body : that of gravity, which tends to make it sink to the bottom, and the upward force of the water tending to thrust the body upwards to the surface. Whether the body shall float, or sink to the bottom, or remain stationary at a certain depth, depends on the relative intensities of these two forces.

Over 2,000 years ago Archimedes stated the law governing the amount of upward pressure to which a body is subjected when placed in a liquid. He found that *a body immersed in a liquid is buoyed up with a force equal to the weight of the liquid it displaces.* If a cubic foot of the liquid weighs the same as a cubic foot of the solid—*i.e.*, if their specific gravities are the same—the body would remain at rest at any depth ; if, as in the case of lead, the solid is specifically heavier than the liquid, the weight of the solid is greater than the weight of the displaced liquid and will sink. And the force with which it will descend equals the difference between their specific gravities. Thus, the specific gravity of lead is 11·38, so that with a cubic foot of water weighing 62½ lb., and a cubic foot of lead weighing 709 lb., the force with which lead would sink is 709 − 62·5 = 646·5 lb. In the case of a light substance such as cork or wood, its weight will be less than the weight of water displaced, and so it will be buoyed upward with a force equal to the difference between the weight of the displaced liquid and the solid. From this it is evident that a floating body such as a cork or a ship displaces its own weight of the water it floats in. Therefore the weight of any floating body may be easily calculated, for it equals the volume of water displaced, in cubic feet, multiplied by 62½ lb. Conversely the draught can be found if the weight and dimensions of the body are known.

The fact that a swimmer cannot sink in the Dead Sea, and that coins, stones, etc., float easily on mercury, is easily explained by the principle of Archimedes. The sp. gr. of Dead Sea water is 1·2 as compared with ·89 for the human body (alive). A living person would thus displace a quantity of water of greater

weight than his own body, and hence would be thrust upwards till he reached the surface. The sp. gr. of mercury is 13·58. A cubic foot of mercury weighs over 7½ cwt., but there are very few solids a cubic foot of which would weigh so much. Therefore, when immersed in mercury they displace a volume of the liquid of considerably greater weight than their own, and so rise. Even when floating, the solid will only displace its own weight of mercury, and hence in many cases only the slightest fraction of a solid will sink below the surface.

water displaced at B. This latter point is called the *centre of buoyancy*, and the line joining G and B is the *axis of flotation*. Now, if a force be applied to the floating body so that it heels over as in **79, 80**, the centre of gravity of the water displaced will be shifted, as shown, and the point M, where a vertical line from the new centre of buoyancy cuts the axis, is the *metacentre*. It is important to remember that the pressure of the water acts upwards in the direction of this line. In **78** G and B are in the same vertical line, and the body floats in equilibrium. If



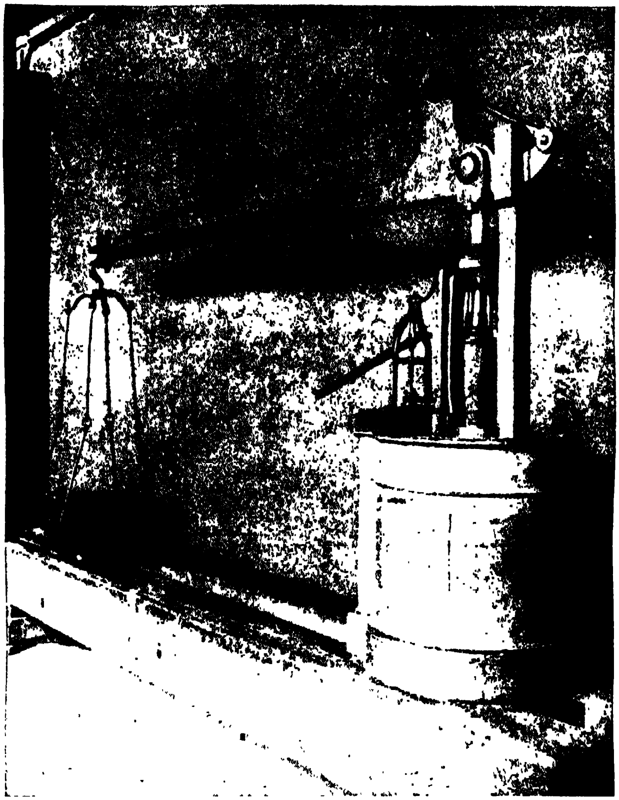
71-80. LIQUID PRESSURE AND ITS UTILISATION

The Metacentre. The stability of a floating body depends upon the position of that important point called the metacentre. In a ship, for example, the position of this point means all the difference between regaining the vertical and capsizing when rolling in a rough sea. The two forces which keep a floating body in equilibrium—(*a*) the downward force of gravity and (*b*) the upward pressure of the water (equal to the weight of water displaced)—may be considered to act (*a*) through the centre of gravity of the body, at G in **78**, and B, which is the resultant of all the upward and parallel pressures through the centre of gravity of the water displaced at B.

it be disturbed, B will change its position with every change in the position of the body, but if, as in **79**, the point where the vertical line from B cuts the axis lies above the centre of gravity, the upward thrust, acting in the direction of this line, will tend to make the body regain its former position. It is then said to be in "stable" equilibrium. But should this metacentre fall below the centre of gravity [**80**], the force acting through BM will tend to make the body depart still more from its original position until it finds a new position of equilibrium. This, of course, means upsetting or overturning, and is termed "unstable" equi-

librium. It may happen that the relative positions of B and G are not changed by the disturbance of a floating body, and that the line BM meets the axis of flotation always at G. This is so in the case of a sphere or cylinder turning on its longitudinal axis. We then have an example of "indifferent" or "neutral" equilibrium. Ships are ballasted in order to bring the centre of gravity so low down that the metacentre shall always be above it.

Practical Examples. In selecting practical examples of hydrostatics, far more must be omitted than can be illustrated, because the applications of water-power are so numerous and important. They occur in shops and factories, in docks and harbours, in warehouses and stores, in small and large installations. They are used in many trades, and are more adaptable to some operations than any other power agency, while in some they have an absolute monopoly. Water-power is silent and strong, silent though squeezing white-hot steel with a pressure of 8000, 10,000, or 14,000 tons, or while opening the huge gates of docks, or pressing hay and fodder into bales, or lifting a trifle of 100 tons. It is capable, too, of the most precise and minute regulation within fractions of an inch, by the control of the water supply. In some spheres of action it is being ousted by electricity, but a wide and undisputed field is still retained by water. The principle underlying all this great group of pressure machinery is that of difference in areas, embodied in the old Bramah press, and its modern equivalent [76]. A photograph of a model at South Kensington of the original hydraulic press made by Bramah is shown in **81**. Pressure is proportional to area, so that the elements of design are absolutely simple. The difficulties which arise are those of risk of leakage, those due to friction—which is considerable—and the necessity for securing ample strength in cylinders subjected to pressures that ordinarily range from 700 to 2000 lb. on every square inch, or still more in some cases.



81. MODEL OF BRAMAH'S ORIGINAL HYDRAULIC PRESS

Head of Water Unnecessary. The problems of *head* of water have been considered in previous paragraphs. But the machinery in question does not now utilise natural head in order to obtain pressure, though that was done in the early days of the hydraulic cranes. Water was pumped continuously up into a tank placed at a great height, and the head of water thus obtained was made available by pipes wherever it was wanted. But this system had obvious inconveniences that restricted its use. A convenient spot was not always possible for the erection of the high tower to carry the tank, while the elevation of the tank was an expensive matter.

Not until Armstrong invented the accumulator did the success of the water-pressure system become assured. This consisted originally of a large cast-iron cylinder filled with a loaded plunger to impart pressure to the water. At once the gravity pressure of some 60 lb. to the square inch was abandoned for 600 lb. In an ordinary hydraulic plant, therefore, we have three elements—the accumulator for water storage under pressure, the force pumps and engines, by which the pressure is produced, and the working cylinder, or cylinders and rams, by which pressure and movement are applied to any particular mechanism, and which occurs in an immense number of forms.

We shall next proceed to give a very concise summary of *hydrostatic* mechanism, or, as it is commonly termed, *hydraulic* machinery.

At the basis of it all lies the pump in some form or other. The common lift or suction pump of wells and tanks plays but a small part here, but combined with another form, the plunger, it is a valuable agent for lifting water from great depths. Few mechanisms are varied more than are lifting-pump valves. Deep and shallow wells, different kinds of liquids, clean or dirty, hot or cold, questions of accessibility, and so on, require modifications in valves.

JOSEPH G. HORNER

Latin: Roman Money and Sequence of Tenses. English: Prepositions and Punctuation. French: Adjectives. German.

LATIN Continued from page 1311

By Gerald K. Hibbert, M.A.

SECTION I. GRAMMAR

Irregular Verbs: Third Conjugation

The following are the most important:

A. CONSONANT VERBS

Guttural Stems, -si, -tum (five, *-sum*)

dico	dixi	dictum	*say*
duco	duxi	ductum	*lead*
cingo	cinxi	cinctum	*surround*
coquo	coxi	coctum	*cook*
fingo	finxi	fictum	*fashion*
pingo	pinxi	pictum	*paint*
jungo	junxi	junctum	*join*
tego	texi	tectum	*cover*
-stinguo	stinxi	stinctum	*quench*
tinguo	tinxi	tinctum	*dye*
unguo	unxi	unctum	*anoint*
traho	traxi	tractum	*draw*
veho	vexi	vectum	*carry*
vivo	vixi	victum	*live*
struo	struxi	structum	*pile*
-lacio	lexi	lectum	*entice*
-specio	spexi	spectum	*espy*
fluo	fluxi	fluxum	*flow*
figo	fixi	fixum	*fix*
mergo	mersi	mersum	*drown*
spargo	sparsi	sparsum	*sprinkle*
tergo	tersi	tersum	*wipe*

Dental Stems, -si, -sum.

claudo	clausi	clausum	*shut*

Similarly, divido, lædo, ludo, plaudo, rado, rodo, trudo, and vado. Also:

cedo	cessi	cessum	*yield*
mitto	misi	missum	*send*
quatio	(quassi)	quassum	*shake*
flecto	flexi	flexum	*bend*
necto	nexi	nexum	*bind*

Labial Stems, -si, -tum.

carpo	carpsi	carptum	*pluck*

Also repo, scalpo, serpo, nubo (nupsi), and scribo (scripsi).

Liquid Stems, -si, -tum (one, *-sum*).

como	compsi	comptum	*adorn*

Also demo, promo, sumo, temno, premo (pressi, pressum), gero (gessi, gestum), uro (ussi, ustum).

Stem various, -ui, -tum (one, *-sum*).

cumbo	cubui	cubitum	*lie down*
elicio	elicui	elicitum	*entice forth*

Also strepo, fremo, gemo, tremo, and vomo.

rapio	rapui	raptum	*seize*
alo	alui	altum	*nourish*

Also colo (colui, cultum), consulo, occulo, pono (posui, positum), gigno (genui, genitum), texo (texui, textum), sero = I join (serui, sertum), and meto (messui, messum).

Present Stem Anomalous, -vi, -tum.

lino	levi	litum	*smear*
sino	sivi	situm	*allow*
cerno	crevi	cretum	*sift, discern*
cresco	crevi	cretum	*increase* (intrans.)
sperno	sprevi	spretum	*despise*
sterno	stravi	stratum	*strew*
sero	sevi	satum	*sow*
nosco	novi	notum	*know*
pasco	pavi	pastum	*feed*
suesco	suevi	suetum	*be accustomed*
quiesco	quievi	—	*rest*
cupio	cupivi	cupitum	*desire*
peto	petivi	petitum	*ask*
quæro	quæsivi	quæsitum	*seek*
tero	trivi	tritum	*rub*
arcesso	arcessivi	arcessitum	*send for*
lacesso	lacessivi	lacessitum	*provoke*

-i, -sum (one, *-tum*).

pando	pandi	pansum (passum)	*spread*

Also scando, prehendo, -cando, -fendo, verto (verti, versum), bibo (bibi, bibitum), vello (velli or vulsi, vulsum).

findo	fidi	fissum	*cleave*
scindo	scidi	scissum	*tear*

Roman Money

Most of the Roman weights and measures were divided by fractions which were originally parts of the *As* or pound weight, containing twelve ounces. The *As* was thus divided:

Unciæ, *i.e.*, Ounces.		Fractions of As.
12	As, *a pound*	1
11	Deunx (de-uncia), *an ounce off*	$\frac{11}{12}$
10	Dextans (desextans), *a sixth off*	$\frac{5}{6}$
9	Dodrans (dequadrans), *a fourth off*	$\frac{3}{4}$
8	Bes, or Bessis (dui-assis)	$\frac{2}{3}$
7	Septunx (septem unciæ), *seven ounces*	$\frac{7}{12}$
6	Semissis, or Semis (semi-assis)	$\frac{1}{2}$
5	Quincunx (quinque unciæ)	$\frac{5}{12}$
4	Triens, *a third*	$\frac{1}{3}$
3	Quadrans, *a fourth*	$\frac{1}{4}$
2	Sextans, *a sixth*	$\frac{1}{6}$
1	Uncia, *an ounce*	$\frac{1}{12}$

Other fractions used were *Sescuncia* ($1\frac{1}{2}$

ounces), *Semuncia* ($\frac{1}{2}$ ounce), *Sicilicus* ($\frac{1}{4}$ ounce), *Sextula* ($\frac{1}{6}$ ounce), *Scripulum* ($\frac{1}{24}$ ounce).

Interest on Money. After B.C. 80 legal interest was fixed at the rate of $\frac{1}{100}$ of the Capital *per month*, called Centesima (sc. *pars*)—*i.e.*, 12 per cent. *per annum*. Lower rates than this were denoted by the fractional parts of the *As* (the Centesima being taken as the As). Thus, reckoning the percentage as per annum :

12 per cent. = *usuræ centesimæ*, or *asses usuræ*.
11 per cent. = *usuræ deunces*
8 per cent. = *usuræ besses*
5 per cent. = *usuræ quincunces*
1 per cent. = *usuræ unciæ*

Higher rates than 12 per cent. were denoted by distributives :

24 per cent. = *binæ centesimæ*
60 per cent. = *quinæ centesimæ*

Expression of Fractions. 1. All fractions with 1 for numerator are denoted by ordinals, with or without *pars* : $\frac{1}{3}$ = *tertia*, or *tertia pars* ; $\frac{1}{4}$ = *quarta*.

2. All fractions with a numerator less by one than the denominator are denoted by cardinals with *partes* simply : $\frac{2}{3}$ = *duæ partes* ; $\frac{5}{6}$ = *quinque partes*.

3. All fractions with 12, or its multiples, for a denominator, are denoted by the parts of an As, which is taken as the whole :

Heres ex asse = heir to the whole estate.
Heres ex triente = heir to a third
Heres ex semisse = heir to a half.

4. All other fractions are denoted by the cardinal for a numerator, and the ordinal for the denominator : $\frac{4}{7}$ = *quattuor septimæ*.

Expression of Sums of Money. Although the *denarius* (= 10 asses) was the silver coin in most frequent currency, the ordinary unit of reckoning was the *sestertius*, or *nummus* (= $\frac{1}{4}$ denarius, or $2\frac{1}{2}$ asses). The Roman sign for $2\frac{1}{2}$ was IIS—*i.e.*, II. + S(emis). This is now written HS, and is the usual abbreviation for a sestertius. Thus, 7,000 sesterces = *septem millia sestertium* (shortened from *sestertiorum*).

This shortened form *sestertium* was taken for a neuter singular noun, meaning 1,000 sesterces, and so we get such forms as

Sestertia decem = 10,000 sesterces.

For sums of a million sesterces and upwards, adverbial numerals are used—*e.g.*, 1,000,000 sesterces = *decies centena millia sestertium* (or, more usually, just *decies sestertium*).

2,300,000 sesterces = *ter et vicies sestertium*.

To distinguish the meanings, strokes were usually added to the numerals—*e.g.*, HS$\overline{\text{X}}$ = *decem millia sestertium* (10,000) ; HS$|\overline{\text{X}}|$ = *decies sestertium* (1,000,000).

Section II. SYNTAX.

Sequence of Tenses. 1. If the verb in the principal clause is in a *primary* tense (*i.e.*, present, future, or true perfect), the verb in the subordinate clause will be (*a*) in the present subjunctive if present time be denoted ; (*b*) in the perfect subjunctive if past time be denoted—*e.g.* :

Rogavi ut illi ignoscatur = I have asked that he may be pardoned.

Cognoscam cur venerit = I will ascertain why he came.

2. But if the verb in the principal clause is in a *historic* tense (*i.e.*, imperfect, simple past, or pluperfect), the verb in the subordinate clause will be (*a*) in the imperfect subj. if present time be denoted ; (*b*) in the pluperfect subj. if past time be denoted—*e.g.*,

Rogavi utrum adesset = I asked whether he were present.

Non dubium erat quin fugisset = there was no doubt that he had fled.

Infinitive Mood. The infinitive is an indeclinable verbal noun. It is used as object, as predicate and as subject, so far as a substantive in the acc. or nom. case would be so used. It is not properly used as a genitive, dative, or ablative, or as an acc. after a preposition. The gerund (also a verbal noun) is used instead.

1. As subject : *Dulce et decorum est pro patria mori* = dying for country is sweet and comely.

2. As object : *Vincere scis : victoria uti nescis* = you know how to conquer, but not how to use your victory.

3. As predicate to a subject in the nom. case ; to express the occurrence of actions without marking the order of time. Often used in narration for a finite verb, hence called historic infinitive—*e.g.*,

Clamare omnes = all cried out.

Rex primo nihil metuere, nihil suspicari = the king at first feared nothing, suspected nothing.

Gerunds and Supines. 1. These are the cases of the infinitive. As mentioned above, the *gerund* is used to express the gen., dat., abl., or acc. after a preposition, of the verbal noun—*e.g.*, *Breve tempus satis longum est ad bene honesteque vivendum* = for living well and honourably, a short time is long enough. *Fugiendo vincimus* = we conquer by fleeing. *Videndi et audiendi delectatio* = the delight of seeing and hearing.

2. The supine in *-um* is an acc. after verbs of motion. It often has a direct, more rarely an indirect, object—*e.g.*, *ibo lusum* = I will go to play.

Deos atque amicos it salutatum ad forum = he goes to hail the gods and his friends at the forum.

Non ego Graiis servitum matribus ibo = I will not go to serve Grecian matrons.

Note. This supine, with *iri* (pass. infin. of *eo*), forms the fut. infin. pass.—*e.g.*, *rectum iri*.

3. The supine in *-u* is used in the abl. to qualify adjectives in a way which may be classed under the head of "part concerned" (abl. of respect)—*e.g.*,

Formæ terribiles visu = forms terrible to see.

Mirabile dictu = wonderful to say.

The Gerundive. 1. The gerundive is confined to transitive verbs. It is usually sub-

stituted for the gerund when the gerund has an object expressed; the object is then attracted into the case of the gerundive, which is made to agree with it in number and gender. *This is very important—e.g., Cæsar comitiali morbo bis inter res agendas correptus est* = Cæsar was twice seized with epilepsy in the midst of transacting business.

Often used (like the supine in *-um*, or the fut. ptc.) to express purpose, instead of *ut* with the subj.:

Missus est a senatu ad animos regum perspiciendos (translate "for the purpose of discovering").

Hi septemviri fuerunt agris dividendis ("for dividing lands").

NOTE. The gerundive is used from *utor, fruor, fungor, potior,* all these verbs being originally transitive.

2. The impersonal gerundive implies necessity, principally in intransitive verbs. This is the usual construction for expressing "must," and the agent is usually put in the dat., not in the abl. with *a* or *ab*:

Bibendum est mihi = I must drink (literally, it is to be drunk by me).

Suo cuique judicio utendum est = each must use his own judgment.

3. The gerundive is often used as a mere attribute or adjective, meaning obligation, destiny, desert, or possibility.

Deus et diligendus est nobis et timendus = God is both to be loved and feared by us.

Eis otium divitiæque, optanda alias, oneri miseriæque fuere = to them leisure and riches, things desirable in other circumstances, were (for) a burden and a misery.

To be turned into Latin Prose.

HOW TO PROCURE CONTENTEDNESS.

By Jeremy Taylor.

If then thou fallest from thy employment in public, take sanctuary in an honest retirement, being indifferent to thy gain abroad or thy safety at home. If thou art out of favour with thy prince, secure the favour of the King of kings, and then there is no harm come to thee. And when Zeno Citiensis lost all his goods in a storm, he retired to the studies of philosophy, to his short cloak and a severe life, and gave thanks to fortune for his prosperous mischance. When the north wind blows hard and it rains sadly, none but fools sit down in it and cry: wise people defend themselves against it with a warm garment or a good fire and a dry roof. When a storm of a sad mischance beats upon our spirits, turn it into some advantage by observing where it can serve another end, either of religion or prudence, or more safety or less envy: it will turn into something that is good, if we list to make it so.

Latin Version of the Foregoing.

Honore amisso in honestum otium quasi in templum defugito, neve pluris lucrum foris quam domi securitatem facito. Et studio regio verso, modo tibi faveat Deus, nihil tibi damno fuerit. Zeno enim Citiensis re inter procellam amissa ad sapientiæ studium togamque brevem et duriorem victum ubi recesserat, fortunæ gratias egit quod sibi ita opportune nocuisset. Et aquilone acri, tristi imbre, soli stulti sedentes flent, sapientis est se toga, igne, tecto defendere. Et ubi malæ fortunæ tempestas in nos inciderit, docet hoc ipsum in lucrum vertere, spectato an ad aliud quid prosit, sive ad fortiores sive ad sapientiores reddendos, sive ad securitatem dandam, sive ad invidiam arcendam. Omnia enim in melius verti potuerint, modo ipsi hoc velimus.

Section III. Translation.

Horace warns Lyce that he cannot put up with her unkindness for ever.

Extremum Tanain si biberes, Lyce,
Sævo nupta viro, me tamen asperas
Porrectum ante fores objicere incolis
    Plorares Aquilonibus.
Audis quo strepitu janua, quo nemus
Inter pulchra satum tecta remugiat
Ventis, et positas ut glaciet nives
    Puro numine Jupiter ?
Ingratam Veneri pone superbiam,
Ne currente retro funis eat rota.
Non te Penelopen difficilem procis
    Tyrrhenus genuit parens.
O, quamvis neque te munera nec preces
Nec tinctus viola pallor amantium
Nec vir Pieria pellice saucius
    Curvat, supplicibus tuis
Parcas, nec rigida mollior æsculo
Nec Mauris animum mitior anguibus.
Non hoc semper erit liminis aut aquæ
    Cælestis patiens latus.

English Version of Above.

Even though you drank of the far-distant Tanais, Lyce, wedded to a savage husband, still you would grieve to expose me, stretched before your cruel doors, to the north winds of the land. Do you hear how loudly the door, how loudly the grove planted within your fair abode groans beneath the blast, and how Jove, with his clear influence, freezes the fallen snows? Lay aside the pride displeasing to Venus, lest rope and wheel run back together. 'Twas not to be a Penelope unyielding to suitors that your Tuscan father begot you. O, although neither gifts nor prayers nor lovers' paleness with its violet hue, nor husband smitten with love for a Pierian mistress, can bend you, yet spare your suppliants, though not more pliant than the unbending oak nor gentler in heart than Moorish serpents. Not for ever will this body of mine endure your threshold or the rain of Heaven.

Continued

ENGLISH

Continued from page 1313

By Gerald K. Hibbert, M.A.

PREPOSITIONS

A preposition is a word which shows how things, or their actions or attributes, are related to other things—*e.g.*, "The man *in* the moon" (*in* showing the relation of the thing *man* to the thing *moon*); "Coming *through* the rye" (*through* showing the relation of the action *coming* to the thing *rye*); "London is full *of* people" (*of* showing the relation of the attribute *full* to the thing *people*). The noun or pronoun following a preposition (and no other part of speech can follow a preposition) is in the objective case, "governed by" the preposition.

Prepositions were originally prefixed adverbially to verbs; they were, in fact, adverbs of place. Thus, "He took the ring *off* his finger," used to be "he *off*-took the ring his finger," *ring* being direct object, and *finger* indirect. Gradually they were detached from the verb, and became prefixed to the noun or pronoun constituting the indirect object, losing in the process the force of adverbs and becoming prepositions. We have still some of these compound verbs remaining, as *overreach*, *undertake*, *upbring*, *withstand* (stand against), *withdraw* (draw from), *gainsay* (say against).

Classification of Prepositions. Prepositions may be classified as *Simple* and *Compound*. The simple prepositions are *at*, *by*, *for*, *from*, *in*, *of*, or *off*, *on*, *through*, *till*, *to*, *up*, *with*.

The most important compound prepositions

aboard	beneath
about	beside(-s)
above	between
across	betwixt
against	beyond
along	but (by-out)
amid(-st)	down, adown
among(-st)	except
anent (= concerning)	inside
(a)round	outside
aslant	since
astride	toward(s)
athwart	underneath
before	after } formed by the
behind	over } comparative
below	under } suffix *-er*.

Nearly all in this list are compounded of a preposition and an adverb, or a preposition and a substantive. The initial *a* in these compounds represents *on*, and *be* represents *by*. Thus, *beside* = by side, *aboard* = on board. In *into*, *unto*, *until*, *upon*, *within*, *without*, *throughout*, we have an adverbial particle prefixed to a simple preposition.

NOTES. 1. *Beside* is used of *place*, to denote either nearness to, or remoteness from: thus, "Blessed are ye that sow *beside* all waters" (meaning *by the side of*); "Whether we be *beside* ourselves, it is to God" (meaning *out of ourselves*, *out of our minds*). When, however, the sense of *over and above* is intended, *besides* is generally used, as "*Besides* Latin, he is also learning Greek."

2. *But* is a preposition when it means *except*. It should then be followed by the objective case, as "No-one was saved but *me*." Consequently, in

> "The boy stood on the burning deck
> Whence all but *he* had fled,"

there is a grammatical error.

3. *Adown* is literally "off the hill," *dune* or *dun* meaning *hill*.

4. Two prepositions, now obsolete, are found in Shakespeare, Milton, and other early writers—*sans* and *maugre*. *Sans* is the French preposition, meaning *without*—*e.g.*, "a confidence *sans* bound" (*Tempest*). *Maugre* is the French *malgré*, in spite of—*e.g.*, "*Maugre* the Roman" (*Paradise Regained*).

Certain participles, such as *considering*, *concerning*, *respecting*, *pending*, *during*, *notwithstanding*, *saving*, *save*, are often used as prepositions, though they are not really such. Thus, in "*Notwithstanding* your cruelty, I forgive you," the true construction is, "Your cruelty *notwithstanding*, I forgive you," the first three words being in the nominative absolute, and *notwithstanding* filling its proper part as a participle. Similarly, in "*Considering* all things" ("all things considered"), "*Pending* his arrival, I felt much excited" ("his arrival pending"), and so on.

Many prepositions are also adverbs, but it is easy to distinguish the two uses. If the word in question governs a noun or some substitute for a noun, it is a preposition; if not, it is probably an adverb. We say "probably," because it might be a conjunction, or even occasionally some other part of speech.

Examples: "He walked *along* the river" (preposition). "He walked *along* very fast" (adverb). "*Since* his death, I have lived here" (preposition); "He died long *since*" (adverb); "*Since* he is dead, we must not speak evil of him" (conjunction).

In "But me no buts," *but* is used first as a verb, secondly as a noun.

When *to* is used as an adverb, it is usually spelt *too* ("Thou wast a spirit *too* delicate To act her earthy and abhorr'd commands").

Place of the Preposition. A preposition should, if possible, immediately precede the word which it governs. Even in relative and interrogative sentences this order should be observed. It is better and more dignified to say "Of whom are you speaking?" than "Whom are you speaking of?" When, however, in a relative sentence, the relative pronoun is omitted, the preposition is usually placed at the end of

the sentence—as: "He is not a man I am fond of" (*i.e.*, "of whom I am fond").

CONJUNCTIONS

Conjunctions are words which join sentences together—as: "I will wait *till* you come." Here *till* joins together the two sentences "I will wait" and "you come." Not every word, however, that connects two sentences, is a conjunction, for we have seen that relative pronouns (*who*, *which*, etc.) and relative adverbs (*when*, *where*, etc.) often connect one sentence with another. With these two exceptions, all words which join sentences together are conjunctions.

The conjunction *and* is peculiar, because, in addition to joining two sentences, it can also join two words, provided they are both of the same kind and stand in the same relation to some other word in the sentence—*e.g.*, "two *and* two are four," "egg *and* milk is a good mixture." But in a sentence like "My parents and my cousins are here," *and* joins two *sentences* ("My parents are here" and "My cousins are here"), not two *words*. *And* is the only conjunction that can join words, though it is sometimes said that *but*, *or*, and *nor* join words. We shall find, however, that in every case these conjunctions really join sentences—*e.g.*, "Neither this nor that is right" stands for "This is not right, that is not right." Such sentences are contracted Compound Sentences.

Classification of Conjunctions. Conjunctions are divided into *Co-ordinative* and *Subordinative*.

Co-ordinative Conjunctions join co-ordinate sentences, that is, sentences of the same rank (Latin *ordo* = rank), neither of which is dependent on the other. The co-ordinative conjunctions are *and*, *both*, *but*, *either*, *or*, *neither*, *nor* (and, according to some grammarians, *because*, *for*, *as*, and *whether*).

Either is the distributive pronoun, and *whether* the relative pronoun, used as conjunctions [See Pronouns]—*e.g.*, "*Either* of the two suits me" (pronoun); "*Either* you or I shall perish" (conjunction).

Or is a shortened form of *either*. *Neither* and *nor* are for *ne-either* and *ne-or*.

But was originally a preposition, meaning *without*, *except*. In phrases like "I cannot but think," "There is no-one but knows," it is a conjunction; also in all cases where it joins two sentences, as "Strike, but hear me," "He loved not fatherland, but himself."

Subordinative Conjunctions join subordinate clauses to a main clause, that is, they unite sentences one of which is dependent on the other—*e.g.*, "He'll be hanged yet, *though* every drop of water swear against it." Here, the second clause depends on the first, or is subordinate to it, therefore the conjunction uniting them is subordinative. Such a sentence as the above is called a *complex* sentence, as opposed to a compound sentence, which consists of two or more co-ordinate clauses united by a co-ordinative conjunction. In a complex sentence, one clause is called the principal clause, and all the other clauses are called subordinate. These subordinate clauses play the part of adverbs, adjectives, or substantives, and are called accordingly, *Adverbial*, *Adjectival*, or *Substantival Clauses* [see next lesson].

The most important subordinative conjunctions are:

1. *That*, introducing substantival clauses—*e.g.*, "He said that he was cold."
2. *If*, *unless*, *except*, etc. (conditional).
3. *Though*, *although*, *albeit* (concessive).
4. *That*, meaning "so that" (consecutive)—as: "It was so cold that the water froze."
5. *That*, meaning "in order that," *lest* (final)—as: "He went out that he might get warm."
6. *After*, *before*, *till*, *until*, *ere*, *since*, *now*, *while*, *as* (temporal).
7. *Because*, *since*, *for*, *as* (causal).
8. *Than* (comparative).

Notes. The conjunction *that* is really the demonstrative pronoun. "He said that he was cold" was originally "He was cold: he said *that*," two co-ordinate sentences. Now one has become subordinate to the other.

Because = "by the cause that," and *albeit* is shortened from "all be it."

Than is now regarded as a conjunction, though it is strictly a relative adverb, meaning *when*, *at which time*. Therefore "The sun is larger than the moon" means "When the moon is large, the sun is larger." Both *than* and *then* are derived from *that*. The noun or pronoun following *than* may be in the nominative case or in the objective, according to the predicate to be supplied, thus: "He hates me more *than* you" may mean "He hates me more than he hates you" (*you* being objective), or "He hates me more than you hate me" (*you* being nominative). Such a sentence as "No one knows better than *me* what I have lost" is, of course, incorrect: it should be "than I [know]."

As was pointed out in dealing with relative pronouns, a relative pronoun following *than* is always put in the objective case, even when it is strictly nominative—as: "Cæsar is dead, than *whom* no greater Roman ever lived." *Whom* ought to be in the nominative, as the sentence stands for "Cæsar is dead, and no greater Roman ever lived than *he*."

It will be noticed that many of the subordinative conjunctions take a verb in the subjunctive mood, but as was pointed out in dealing with the subjunctive, the conjunction is no part of the mood.

INTERJECTIONS

These are words interjected or "thrown in" to express some emotion. They do not stand in any grammatical relation to other words, and are independent of the construction of the sentence

Examples: *Hurrah! Alas! Oh! Ah! Pshaw! Ha, Ha! Good-bye!* (God be with you), *Hullo! Whoa! Welcome! Hail! Adieu!*

PUNCTUATION

Punctuation is the right method of inserting stops (Latin *puncta*, points). Stops are written marks to represent oral pauses. If we speak to anyone for a few minutes, and notice carefully the manner of our speech, we shall find that we make pauses of greater or less duration, mainly —though not entirely—for the sake of clearness. If our remarks were then written down, these different pauses would be represented by different stops.

Marks of Punctuation. 1. Where we completed a sentence, a *period*, or *full stop*, would be used (.).

2. Where we made a decided pause, but not so decided as in the first case, a *colon* (:) or *semi-colon* (;) would be used.

3. Where only a slight pause was made, a *comma* (,) would be used.

These words are not strictly names of *stops*, but of the portions of sentences which they mark off. Thus, *period* means " a circuit," a complete sentence ; *colon* means " a limb," a member of a sentence ; and *comma* means " a section " of a sentence—something cut off, a clause. In Shakespeare *comma* has this meaning of a short part of a sentence. A *semi-colon* is a half-colon. The meaning of a sentence ought to be plain without the aid of any stops whatever. Stops are comparatively a modern invention ; they do not appear on ancient manuscripts, and at one time they were not allowed in our Acts of Parliament. At the present day, too, in legal documents stops are usually conspicuous by their absence.

Very often the entire meaning of a sentence can be altered by a slight alteration of punctuation—a fact of which full advantage is taken in many riddles that are propounded, and in many traps that are set for the unwary. Thus, in the well-known statement, " King Charles walked and talked half an hour after his head was cut off," nonsense becomes sense by the insertion of a colon after " talked." Again :

" Every lady in this land
Has ten fingers on each hand
Five and twenty on hands and feet
This is true without deceit."

Further instances will occur to everybody. Who, for example, has not heard of the advertisement, "A piano for sale by a lady about to cross the Channel in an oak case with carved legs" ?

Uses of the Stops. The *full-stop* is used to mark the completion of a whole sentence, whether simple or complex. It is also used after abbreviations—as *i.e.*, R.S.V.P., Rev., D.D.

The *colon* originally marked off the parts of a compound sentence. It is now used after a sentence which, though grammatically complete, is followed by another sentence closely connected in sense. In such cases a full-stop would mark too great a break. For example, in Sir Walter Scott's "Autobiography": " My father had a zeal for his clients which was almost ludicrous : far from coldly discharging the duties of his employment towards them, he thought of them, etc."

Again :

" Cowards die many times before their deaths :
The valiant never taste of death but once."

A colon is also used to introduce a quotation. For example : A forgotten satirist well says :

" The active principle within
Works on some brains the effect of gin."
(Lockhart's "Life of Scott.")

The *semi-colon* is a modern form of the colon. It is impossible to lay down rules for their respective use, but, roughly speaking, the semi-colon marks a less complete pause than the colon. The semi-colon is usually placed between the co-ordinate members of a compound sentence *when the connection is marked by a conjunction*—as : " Thou dost here usurp the name thou owest (ownest) not ; and hast put thyself upon this island as a spy " ("Tempest"). If the sentences are short, and closely connected in meaning, commas are used instead of semi-colons—as :

" We carved not a line, and we raised not a stone,
But we left him alone in his glory."

Sometimes not even a comma is needed—as :

" He was born and died in London."

The *comma* is not used to-day as frequently as in former days. A sentence should not be overloaded with commas ; they should be used only where it is absolutely necessary for the sake of clearness. Common-sense must be the guiding element in their usage. But a few points may be mentioned :

1. A comma should be used to mark the end of a substantive clause forming the *subject* of a verb—as : " That the days are longer in summer than in winter, admits of no dispute." But if the clause either follows the verb, or is the object of the verb, no comma is used—as : " He said that he was cold."

2. In a list of words of the same nature—nouns, adjectives, adverbs, etc.—brought together in the same connection, a comma is inserted after each word except the second last when it is followed by " and "—as : " With an humble, lowly, penitent and obedient heart " (Prayer Book).

3. The comma is used after an adverbial clause that comes before the verb which it modifies—as : "When he comes, tell me." But if the adverbial clause *follows* the verb, the comma is not needed—as : "Tell me when he comes."

4. There is no need of a comma between the antecedent and the relative pronoun if the relative introduces a limiting, or restricting, clause ; but if the relative is continuative or ampliative [see page 523] a comma must be introduced. The two examples quoted on page 523 well illustrate this :

Restrictive. " He broke the pen which I lent him."

Continuative. " His eldest son, whom he had lost many years before, had always been his favourite."

5. A comma is used to separate a noun in the Vocative (or Nominative of Address) from the rest of the sentence—as : "Thou spirit, who led'st this glorious eremite into the desert." (Milton.)

Continued

FRENCH

Continued from page 1315

By Louis A. Barbé, B.A.

POSITION OF ADJECTIVES

1. It very largely depends upon euphony whether an adjective is to be placed before or after the noun which it qualifies. In accordance with it, the following general principle may be laid down: monosyllabic nouns are seldom preceded by adjectives of several syllables.

2. Use has established the following rules:

(*a*) The adjectives *beau*, beautiful; *bon*, good; *cher*, dear (loved); *gentil*, pretty, nice; *grand*, large; *gros*, big; *jeune*, young; *joli*, pretty; *long*, long; *mauvais*, bad; *meilleur*, better; *petit*, small; *pire*, worse; *sot*, stupid; *vaste*, vast; *vieux*, old; *vilain*, ugly, usually precede the adjective.

(*b*) The ordinal numbers: *premier*, first; *deuxième* and *second*, second; *troisième*, third, etc., and also *dernier*, last, are placed before the noun; *le premier homme*, the first man; *le vingtième siècle*, the twentieth century. In connection with *semaine*, week; *mois*, month; *année*, year; *siècle*, century, the adjective *dernier* changes its meaning according as it comes before or after the noun, thus: *la semaine dernière*, last week; *l'année dernière*, last year—*i.e.*, immediately preceding the present week, etc. When it is placed before the noun it indicates the last of a particular series, thus: *la dernière semaine du mois*, the last week of the month; *le dernier jour de l'année*, the last day of the year.

(*c*) Adjectives of colour, as *rouge*, red; of shape, as *rond*, round; of taste, as *amer*, bitter; of temperature, as *tiède*, tepid; of nationality, as *français*, French; and of religion, as *protestant*, are placed after the noun, as: *une fleur blanche*, a white flower; *une table carrée*, a square table; *une pomme douce*, a sweet apple; *de l'eau froide*, some cold water; *un soldat anglais*, an English soldier; *un pasteur protestant*, a protestant clergyman.

(*d*) Present participles (which then become verbal adjectives) and past participles follow nouns when they are used to qualify them: *une main tremblante*, a trembling hand; *un homme instruit*, an educated man.

(*e*) Adjectives which end in *al*, *el*, *ic*, *ique*, *able*, *aire*, *oire*, and *ible*, and which are consequently polysyllabic, usually follow the noun: *un voyage sentimental*, a sentimental journey; *un homme spirituel*, a witty man; *un parc public*, a public park; *une réponse catégorique*; a categorical reply; *une femme remarquable*, a remarkable woman; *une dépense nécessaire*, necessary expense; *un ordre péremptoire*, a peremptory order; *un remède infaillible*, an infallible remedy.

(*f*) A change from the literal to a figurative meaning is usually indicated by a change of position: *un habit noir*, a black coat; but *une noire ingratitude*, black ingratitude.

(*g*) In accordance with this, some adjectives in connection with certain nouns have very different meanings, according as they come before or after the noun. This is particularly the case in connection with *homme*:

Un bon homme, a simple, good-natured, man; *un homme bon*, a kind-hearted, charitable man; *un brave homme*, a worthy man; *un homme brave*, a courageous man; *un pauvre homme*, a man of mean capacity; *un homme pauvre*, a man in poor circumstances; *un galant homme*, a chivalrous man; *un homme galant*, a man attentive to ladies; *un honnête homme*, an honourable man; *un homme honnête*, a polite man; *un cruel homme*, a disagreeable man; *un homme cruel*, a cruel, inhuman man.

EXERCISE VIII.

1. The young man's sister has pretty little children.
2. The old houses have large gardens.
3. The month of December (*décembre*) is the last month of the year.
4. He bought (has bought, *acheté*) an ugly, big dog last week.
5. They live (*demeurent*) in a large white house near the ruined (*ruiné*) castle (*château*).
6. There are two round tables in the little square room.
7. Have you any red ink ?
8. No; but I have some black ink and some blue ink.
9. The French language is a romance (*romane*) language.
10. Spain (*l'Espagne*) is a Catholic country; England and Scotland (*l'Ecosse*) are Protestant countries.
11. The child took (*prit*) the money (*argent*) with (*de*) a trembling hand.
12. The old church is near the public park.
13. The French clergyman is a very intelligent and very learned man.
14. There are no infallible remedies.
15. A worthy man is not always (*toujours*) a courageous man.
16. A rich man may (*peut*) be a man of mean capacity.
17. A broad (*large*) and deep (*profond*) ditch (*fossé*, m.) protects (*défend*) the approach (*approche*) of the old castle.
18. Paris is a large and handsome city.
19. They have met with (*rencontré*) insurmountable (*insurmontable*) difficulties (*difficulté*).
20. We have spoken to a very amiable young man.

DEGREES OF COMPARISON

1. There are three degrees of comparison: the positive (*le positif*), the comparative (*le comparatif*), and the superlative (*le superlatif*). The positive is the adjective in its simple form—*bon, petit, mauvais*.

2. **The Comparative.** There are three forms of the comparative: (*a*) the comparative of superiority, (*b*) the comparative of inferiority, and (*c*) the comparative of equality.

(*a*) The comparative of superiority is formed by putting *plus*, more, before the positive, and *que*, than, after it: *Le chien est plus grand que le chat*, the dog is bigger than the cat.

(*b*) The comparative of inferiority is formed by putting *moins*, less, before the positive and *que*, than, after it: *Le chat est moins grand que le chien*, the cat is less big than the dog.

(*c*) The comparative of equality is formed by putting *aussi*, as, before the positive and *que*, as, after it: *Le chat est aussi grand que le chien*, the cat is as big as the dog.

When the comparative of equality is used in a negative sentence *si* may take the place of *aussi*: *Le chat n'est pas si grand que le chien*, the cat is not so big as the dog.

3. **The Superlative.** There are two kinds of superlative—(*a*) the relative superlative, and (*b*) the absolute superlative.

(*a*) The relative superlative is that which, besides expressing a quality in the highest or lowest degree, indicates a comparison between that quality in one object, or class of objects, and the same quality in another object, or class of objects.

The relative superlative may be a superlative either of superiority or of inferiority.

The superlative of superiority is formed by putting the definite article *le*, *la*, or *les* before the comparative of superiority: *L'éléphant est le plus fort des animaux*, the elephant is the strongest of animals; *elle est la moins jolie des trois sœurs*, she is the least pretty of the three sisters.

When the superlative is preceded by a possessive adjective, the article is left out: *Mon plus beau tableau*, my finest picture.

When the superlative adjective comes immediately after the noun, two articles are required—one before the noun, the other before the superlative: *Les animaux les plus féroces*, the most ferocious animals; *les hommes les moins intelligents*, the least intelligent men.

In this construction when there is a possessive it takes the place of the first article only: *Mes élèves les plus avancés*, my most advanced pupils. When there is a preposition before the superlative it affects the first article only: The opinion of the most intelligent men, *l'opinion des hommes les plus intelligents.*

The preposition "in," which frequently follows the superlative in English, is rendered by *de* in French: The most beautiful flower in the garden, *la plus belle fleur du jardin.*

The English rule with regard to the use of the comparative when only two objects are compared, and of the superlative when more than two are compared, is unknown in French: The taller of the two, *le plus grand des deux*; the tallest of the three, *le plus grand des trois.*

"More than," "less than" before a numeral do not necessarily imply a comparison, but only excess or want. In that case they are expressed by *plus de, moins de*: He has more than three francs, *il a plus de trois francs.* When there is a real comparison, in which case the verb is understood after the numeral, "than" is rendered by *que*: Two dogs eat more than four cats (eat), *deux chiens mangent plus que quatre chats.*

(*b*) The absolute superlative is that which carries the quality of an object to the highest (or lowest) degree, but does not imply a comparison with any other object. It is formed by putting some such word as *très*, very; *bien*, very; *fort*, greatly; *extrêmement*, exceedingly, etc., before the adjective. *Le plus*, most, and *le moins*, least, may also be used absolutely; but, in that case, the definite article *le* is invariable.

4. **Irregular Comparisons.** (*a*) The adjective *bon*, good, is compared irregularly: *bon*, good; *meilleur*, better; *le meilleur*, best.

(*b*) *Petit*, small, has both a regular and an irregular comparison: *petit*, small; *plus petit*, smaller; *le plus petit*, smallest; and also *petit*, small or little; *moindre*, less; *le moindre*, least. The regular form is used to express size: *le plus petit des enfants*, the smallest of the children. The irregular form is more commonly used with reference to importance, value, etc.: *le moindre soupçon*, the least suspicion.

(*c*) *Mauvais*, bad, has both a regular and an irregular comparison: *mauvais*, bad; *plus mauvais*, worse; *le plus mauvais*, worst; and also, *mauvais*, bad; *pire*, worse; *le pire*, worst. The regular form indicates the actual badness of an object: *La bière est plus mauvaise que le vin*, the beer is worse (*i.e.*, of worse quality) than the wine. The irregular form refers more particularly to evil effects, unpleasant consequences, etc. Thus, to express the bad results of over-indulgence in beer and wine respectively, it might be said: *la bière est pire que le vin*, beer is worse than wine.

5. **Irregular Adverbs.** In English these forms of comparison are used both as adjectives and adverbs, thus: His writing is *better* than mine, and, He writes *better* than I. In French, the two parts of speech are different, and must be carefully distinguished from one another:

ADJECTIVE: *Bon*, good; *meilleur*, better; *le meilleur*, best;

ADVERB: *Bien*, well; *mieux*, better; *le mieux*, best.

ADJECTIVE: *Petit*, little; *moindre*, less; *le moindre*, least;

ADVERB: *Peu*, little; *moins*, less; *le moins*, least.

ADJECTIVE: *Mauvais*, bad; *pire*, worse; *le pire*, worst;

ADVERB: *Mal*, badly; *pis*, worse; *le pis*, worst.

Mal has also the regular forms *plus mal, le plus mal.*

EXERCISE IX.

1. The horse is bigger than the ass (*âne*), as big as the ox (*bœuf*), and less big than the elephant.
2. Cats are not so faithful (*fidèle*) as dogs.
3. The tiger is the most ferocious of animals.
4. My finest pictures and my best books are not here (*ici*).

5. Here is the best known (*connu*) of Dumas' novels (*roman*, m).

6. He lives in the smallest house in the village (*village*, m).

7. The least difficulty discourages (*décourage*) lazy (*paresseux*) pupils.

8. He has spent (*passé*) more than three months in France.

9. Three cats eat less than two dogs.

10. The wolf has eaten (*mangé*) more than three sheep.

11. Gold is less useful than iron ; gold is the most precious (*précieux*), but iron is the most useful of metals.

12. The highest (*élevé*) mountain (*montagne, f.*) in Scotland is (has) more than four thousand (*quatre mille*) feet.

13. There is one of the most intelligent pupils in the class.

14. The prettier of the two sisters is not the more amiable.

15. The most bitter fruits are often the most wholesome (*sain*).

16. The remedy is often worse than the evil (*mal*, m.).

17. Doctors (*médecin*) are more useful than barristers (*avocat*).

18. We have (one has = *on a*) often need of one smaller than ourselves (oneself = *soi*).

Key to Exercise VI. (page 1314).

Je regarde par la fenêtre. Devant la fenêtre il y a un grand jardin. Dans le jardin il y a des arbres. Parmi les arbres il y a un bel aubour, un joli lilas, une aubépine, une yeuse et un sorbier. Il y a aussi de grands lauriers. Ils sont toujours verts. L'yeuse aussi est toujours verte. En automne le sorbier a des baies. Elles sont rouges. En hiver le houx a des baies aussi. Les feuilles du houx sont luisantes et piquantes. Au printemps le houx et le sorbier n'ont pas de baies. Au delà des arbres je vois un pont. Sous le pont il y a une petite rivière. L'eau de la rivière est fraîche et claire. Au delà du pont il y a une large rue. La rue a deux trottoirs. Au bord des trottoirs il y a des réverbères. Dans la rue il y a plusieurs personnes. Elles marchent sur le trottoir. Une des personnes est un facteur. Il a un sac plein de lettres. Il y a aussi une voiture et un cheval. Il n'y a pas de charrette. Au bout de la rue il y a une église. Elle a un beau clocher. Le clocher est haut. Il a une girouette. L'église n'est pas vieille, elle est nouvelle. De la fenêtre je vais à la table. Je prends un petit livre. La couverture du livre est bleue. Dans le livre il y a de jolies gravures. Une des gravures représente une ferme. La ferme est dans une grande cour. Elle a une écurie et une étable. Dans l'étable il y a des vaches. La vache donne du lait. L'écurie est la maison du cheval. L'écurie n'est pas un grand bâtiment. Dans l'écurie il y a un jeune cheval et une vieille jument. Près de la ferme il y a un pré. Dans le pré il y a des brebis. Une petite fille garde les brebis. La brebis donne de la laine. La laine de la brebis est utile à l'homme. Derrière la ferme il y a un verger. Dans le verger il y a des pommiers, des poiriers et des cerisiers. Les pommes sont le fruit du pommier. Les pommes sont bonnes quand elles sont mûres. Les cerises sont le fruit du cerisier. Elles sont douces. Les poires sont savoureuses. J'aime la campagne. En été je vais à la campagne. J'ai une petite maison sur une colline agréable. Elle est blanche. Les contrevents sont verts. Le toit est de chaume. Elle est propre et gaie. A la campagne l'exercice donne un nouvel appétit. La faim est une bonne cuisinière. Les mets sont fins. Les repas sont des festins. En hiver je n'aime pas la campagne. Elle est nue et triste. Les arbres n'ont pas de feuilles. Il y a de la neige sur la terre. En hiver j'aime la ville.

Key to Exercise VII. (page 1315).

1. Voilà de beaux livres.
2. Les enfants sont polis.
3. Vous avez de belles oranges.
4. Les bateaux ont des gouvernails.
5. Les pêches et les abricots ont des noyaux.
6. Nous avons donné des prix aux élèves.
7. Les portes n'ont pas de verrous.
8. Les joujoux des enfants sont cassés.
9. Les bijoux de la princesse ont coûté des prix fous.
10. Il y a des choux dans le jardin.
11. Les bergers gardent les troupeaux.
12. Les chevaux sont des animaux utiles.
13. Il n'y a pas de chacals en Angleterre.
14. Les églises ont de beaux vitraux.
15. Les généraux ont des aïeux nobles.
16. Nous n'avons pas besoin d'éventails.
17. Les petites filles ont les yeux bleus.
18. Ils ont donné plusieurs bals.
19. La voûte des cieux est parsemée d'étoiles,
20. Les travaux des hommes sont périssables.

Continued

GERMAN

Continued from page 1179

By P. G. KONODY and Dr. OSTEN

Inflections of Weak Verbs

XIII. In the Imperfect a *weak verb* [see X.] takes the following inflections:

Indicative

Singular

1.	⸗ete or ⸗te	ich lob⸗te	I praised
2.	⸗etest or ⸗test	du lob⸗test	thou praisedst
3.	⸗ete or ⸗te	er lob⸗te	he praised

Plural

1.	⸗eten or ⸗ten	wir lob⸗ten	we praised
2.	⸗etet or ⸗tet	ihr lob⸗tet	you „
3.	⸗eten or ⸗ten	sie lob⸗ten	they „

1. The inflections of the subjunctive are identical with those of the indicative.

2. The first -e of the inflections -ete, -etest, etc. is generally dropped, but retained for euphony's sake in verbs with stems ending

in -d, -n, -ſt, -t: like: bad-en, to bathe: athm-en, to breathe; koſten, to cost or to taste; wart-en, to wait; (1. *sing.* ich bad-ete; 2. du athmet-eſt; 3. er koſt-ete; 1. *plur.* wir wart-eten, etc.). For the same reason the first e of the inflections is sometimes dropped, sometimes retained, in verbs with stems ending in -n. Thus it is dropped in ahn-en, to forebode; gähn-en, to yawn; lern-en, to learn, etc., and retained in öffn-en, to open; rechn-en, to reckon; zeichn-en, to draw or design. (1. *sing.* ich ahn-te; 2. du gähn-teſt; 3. er lern-te; but 1. *plur.* wir öffn-eten; 2. ihr rechn-etet; 3. ſie zeichn-eten).

3. The IMPERFECT is the distinguishing trait of the weak and strong conjugations [see X_1]. Weak verbs form this tense by taking suffixes, strong verbs by changing the stem vowel. Reden (stem: red-) and ſprechen (stem: ſprech-)—either of which signifies, to speak—form the imperfect: ich red-ete (weak) I spoke, and ich ſprach (strong) I spoke, the latter merely changing the stem vowel e into a.

XIV. 1. The PAST PARTICIPLE OF WEAK VERBS is generally formed by the prefix ge- and the suffice -t or -et.

The prefix ge- cannot be added to verbs of foreign origin, like the extensive group of verbs ending in -iren (addi'ren, to add up; citi'ren, to quote; and to verbs with unstressed first syllables (such as those with the prefixes be-, emp-, ent-, er-, ge-, ver-, zer-).

EXAMPLES: lob-en, ge-lob-t; lern-en (to learn), ge-lern-t; begrü'ßen, (to greet), begrüß-t; erlauben, to permit, allow), erlaub-t; and so on.

2 The PRESENT PARTICIPLE of all German verbs is formed by the sufix -end: lob-end, praising; lern-end, learning; red-end, ſprech-end, speaking; and so on.

NOTE. The PROGRESSIVE FORM (auxiliary verb and participle present) is *never* used in German. "I am coming" is expressed by „ich komme" (I come), *never* by „ich bin kommend"; "I was learning," „ich lernte" (I learned), *never* „ich war lernend".

3. The IMPERATIVE (mood of command, desire, and wish) is formed in the weak conjugation by the suffixes -e (*sing.*) and -et or -t (*plur.*).

2. *sing.*	lob-e!	praise!	lern-e!	learn!
2. *plur.*	lob-et!		lern-et!	
civil address	lob-en Sie!		lern-en Sie!	

The suffix -e in the *sing.* and the flective e in the second person *plur.* can in some cases be omitted, but not in verbs with stems ending in d or t, *e.g.*, bad-e! bad-et!, bathe!; red-e! red-et!, speak!

For the sake of emphasis the personal pronoun is sometimes added, either before or after the verb: Du, lerne! or Lerne du! — Ihr, lernet! or Lernet ihr!

4. As in English, the imperative for the first and third person is formed with the help of auxiliary verbs. There are either auxiliary verbs of tense (ſein, haben, werden), or of mood: ſoll-en, ich ſoll (I am to); mög-en, ich mag (I may); müſſen, must; woll-en, ich will (I will, I want to, I wish to); laſſ-en (to let, to allow, to permit, etc.). They are used in the indicative and conjunctive moods, the subject either preceding or following the *finite* verb.

EXAMPLES: Seien wir glücklich! — Let us be happy! Möge [pres. conj.] ich (er) glücklich ſein! — May I (he) be happy! Mag er kommen! — May he come (let him come!) Laſſet uns fleißig ſein! — Let us be diligent! Ihr ſollt (müßt) lernen! — You ought to (must) learn! Es werde Licht! — Let there be light! Er lebe! — May he live! Möchte es ihm gelingen! — May he succeed with it! (*lit.*: May it him succeed).

5. The auxiliary verbs of mood: mögen, may, and laſſen, let, and the conjunctive forms are used where the imperative expresses a wish, desire, or hope; whilst the indicative denotes command. To distinguish this indicative of command from the indicative of the ordinary statement, the sequence of words in the former case is the same as in a sentence of question [see IX.]: Mag er kommen! May he come (let him come!) but: Er mag kommen, he may come.

XV. 1. PREPOSITIONS. The German prepositions govern either the genitive (2), the dative (3), or the accusative (4), or in some cases the two latter alternately, whilst a few govern the genitive and dative alternately. Examples (the governed case is indicated by the figures in brackets): ſtatt, anſtatt (2), instead of; wegen (2), on account of, because of; aus (3), out of, from; bei (3), near, about, with, at, by; mit (3), with; nach (3), after, to, for; von (3), from, of; zu (3), to, at, by; für (4), for; gegen (4), against, towards; ohne (4), without; durch (4), through, by; um (4), around, about, for. The exact employment of these prepositions must be learnt by practice. What the student has to commit to memory is the case governed by each.

The prepositions governing two cases will be treated subsequently.

EXAMPLES; Er redete ſtatt (2) meiner — he spoke instead of me. Ich komme wegen (2) des Schülers — I come on account of the scholar. Wir kommen aus (3) dem Garten — we come from the garden. Ich war mit (3) dem Vater — I was with the father. Er kommt nach (3) Ihnen — he comes after you. Es iſt für (4) das Kind — it is for the child. Wir ſegelten gegen (4) den Wind — we sailed against the wind. Er arbeitete ohne (4) mich — he worked without me. Wir wanderten durch (4) den Wald — we walked through the forest.

XVI. 1. THE STRONG DECLENSION [see V. and VI.] is chiefly taken by the masculine, the majority of the neuter, and a few feminine nouns ending -s, -ſt, -t (die Maus, the mouse; die Nuß, the nut; die Kunſt, the art; die Braut, the bride; etc.) -nis and -ſal (die Kenntnis, the knowledge; die Trübſal, the affliction; etc.) As the nouns of feminine gender remain unaltered in the singular of both the strong and the weak declension, the formation of the plural provides the only clue as to the group to which they belong. The feminines of the strong declension, except

those ending in -niſ and -ſal modify the vowel in the plural.

2. The characteristic feature of the strong declension of masculine and neuter nouns [see VI.] is the suffix -es or -s in the genitive. The -s inflection is taken by nouns

(a) ending in an unstressed -e,
(b) ending in the unstressed syllable -el, -em, -en, or -er,
(c) some substantives of foreign origin,
(d) all diminutives

EXAMPLES: (a) das Gewöl'be, des Gewölbe-s, (vault); (b) der Sattel, des Sattel-s, (saddle); der Athem, des Athem-s, (breath); der Magen, des Magen-s, (stomach); der Fiſcher, des Fiſcher-s, (fisherman); (c) das Ventil', des Ventil-s, (valve); der Tenor', des Tenor-s (the tenor); (d) das Vä'terchen, des Väterchen-s.

3. All other strong substantives take -es in the genitive, but the e is sometimes dropped in nouns that do not have the stress on the last syllable—*e.g.*, der Kö'nig, des König-s (king); der A'bend, des Abend-s, (evening); der Fähnrich, des Fähnrich-s, (ensign); but der Mann, des Mann-es. Nouns with stressed final syllables ending in e drop the *flective* e for reasons of euphony: der Klee, des Klee-s, (clover); das Knie, des Knie-s, (knee). The flective e can also be dropped in the *dative* of nouns ending in hissing sounds (s, ſſ, ß, ſch, z): das Gras (grass), des Graſ-es, dem Graſ-e *or* dem Gras; der Fluß (river), des Fluſſ-es, dem Fluſſ-e *or* dem Fluß; der Wunſch (wish, desire), des Wunſch-es, dem Wunſch-e *or* dem Wunſch; der Tanz (dance), des Tanz-es, dem Tanz-e *or* dem Tanz.

XVII. The POSSESSIVE PRONOUNS are: mein, my; dein, thy; ſein, his; ihr, her; ſein, its; unſer, our; euer, your; ihr, their; each with three genders and a uniform plural for all the three genders. The suffixes shown in the following table serve for *all* possessive pronouns:

Singular

1.	mein (*m.*)	mein-e (*f.*)	mein (*n.*)
2.	mein-es	mein-er	mein-es
3.	mein-em	mein-er	mein-em
4.	mein-en	mein-e	mein

Plural

1.	mein-e
2.	mein-er
3.	mein-en
4.	mein-e

1. The declensive e (*or* the radical e) is sometimes dropped in the declension of unſ-e-r and eu-e-r: unſ(e)r-es or unſer-(e)s; eu(e)r-es or euer-(e)s; unſ(e)r-em or unſer-(e)m; eu(e)r-em or euer-(e)m; etc.

2 The possessive pronoun agrees in gender, number and case with the substantive, when it precedes this substantive (as attributive adjective): mein Hut, my hat; dein-e Weſte, your waistcoat; ſein Hemd, his shirt; der Hut mein-es Vaters, mein-er Mutter, mein-es Kindes, the hat of my father, of my mother, of my child.

3. The third person ſein (*m.* and *n.*) his, and ihr (*f.*) her, agrees in gender with the substantive which it substitutes, but in number and case with the noun it precedes; for instance der König liebt ſein-nen Sohn und ſein-e Töchter, the king loves his son and his daughters.

EXERCISE 1. (*a*) Form the present and past participles of the following verbs, after having ascertained the stem:

ahnen, to forebode, arbeiten, to work, athmen, to breathe, baden, to bathe,
begrüßen, to greet, belächeln, to smile at, upon, erlauben, to allow,
erzählen, to narrate, entzücken, to charm (ravish), erröthen, to blush,
eröffnen, to open (inaugurate), gähnen, to yawn, gehorchen, to obey, gewähren, to grant,
handeln, to act, haſſen, to hate, koſten, to taste, to cost, läuten, to ring,
lieben, to love, loben, to praise, lernen, to learn, lauſchen, to listen, lächeln, to smile,
öffnen, to open, rauchen, to smoke, rechnen, to reckon, to calculate,
reden, to talk, speak, regieren, to govern, röſten, to roast, ſagen, to say, ſegeln, to sail,
ſchnalzen, to smack [one's tongue] ſpielen, to play, to gamble,
ſtören, to disturb, verſagen, to refuse, verſpielen, to lose [at play],
zählen, to count, zeichnen, to draw, zerſtören, to destroy.

(*b*) Insert the missing imperatives:

(*sing.*) ...... die Aufgabe! Learn the lesson! (*pl.*) ...... den Vater! Greet the father!
(*s.*) ...... die Thür! Open the door! (*pl.*) ..... ruhig! Be quiet!
(*s.*) .... beten! Let us pray! (*pl.*) ....! Pray! (*s.*) .... die Glocke! Ring the bell!
(*conj. pres. of to be*) ...... wir ruhig! Let us be quiet!

EXERCISE 2. Insert the missing substantives and pronouns in the cases required by the prepositions.

Die Mutter kommt ſtatt ....
The mother comes instead of the father.
Wir wanderten mit .... durch ....
We walked with the children through the wood.
Er reiſte gegen .... des Onkels
He travelled against the wish of the uncle
wegen .... Er kommt aus ... .
on account of the aunt. He comes from the south
und bringt Geſchenke für ..., für ... und für ... .
and brings presents for me, for him and for the girl.
Der Lehrer lobte uns nach .... Prüfung
The teacher praised us after the examination.
Er kommt nach .... ohne ....
He comes after [the] dinner without a guide
durch ... . Wir beteten für ... .
through the forest. We prayed for the uncle
und für .... nach .... Predigt (*f.*)
and for the aunt after the sermon.
Ich hörte eine Rede ſtatt ....
I heard a speech instead of a song.

Continued

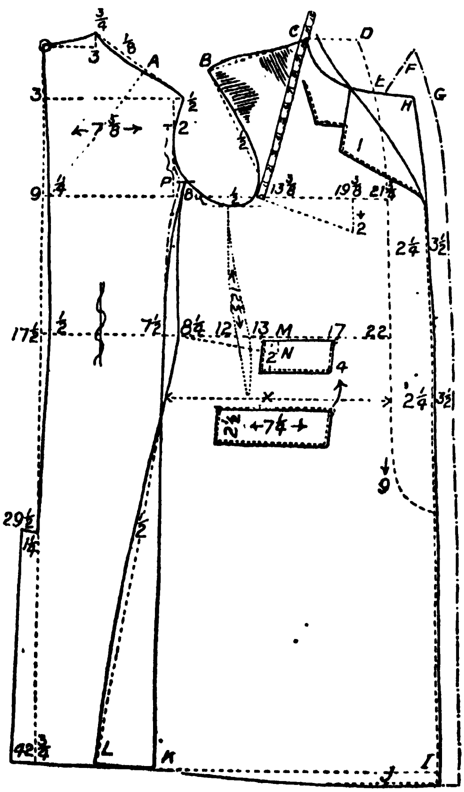
Drafting and Cutting a Chesterfield Overcoat. Four Styles of Vests. Cutting Material from the Cloth. Trimmings. Hints on Making

OVERCOATS AND WAISTCOATS

Overcoats. The most popular style of overcoat is the Chesterfield, and we show how to cut this in two styles—the "fly" front and the "double-breasted." Overcoats, of course, require larger shoulders and larger body parts than the ordinary suit coat, as well as extra spring over the hips. This is provided for by increasing the front and over shoulder measures ¾ in., allowing an extra inch a side for making up and adding about 1 in. more spring at the hips. In order to make this clear we give the system complete.

Draw lines at right angles to 0 [22]. 0 to 3, ¼ scye depth; 0 to 9, depth of scye; 0 to 17½, natural waist length plus ½ in.; 17½ to 29½, from 9 to 12 in.; 0 to 42¾, full length plus ½ in. Square lines at right angles to these points. 17½ to ½ is ½ in.

Draw back seam from 0 through ½ to 29½. Mark back from 29½, 1¼ in., and draw line from 0 through it to bottom. 0 to 3, one-twelfth breast; 3 to ¾, ¾ in. 2 in. below 3 mark off the width of back plus ¾ in., and curve out to ½. Draw shoulder seam from ¾ to ½; ½ to 21¾, half chest plus 3½ in; 21¾ to 13⅜, the across chest plus ⅜ in.; 13⅜ to 19⅜ is always 6 in.



22. CHESTERFIELD OVERCOAT

19⅜ to 2 is 2 in., more for stooping figures and less for erect. Square up from 13⅜ and 2 in the direction of C. 13⅜ to C the front shoulder length, plus ⅜ less 0 to 3 of the back. 13⅜ to B the over shoulder measure, plus ⅜ less ½ to A of the back; C to B, ¼ in. less than back shoulder.

Shape scye by those points, dropping it ½ in. below line 9; ½ to 7½ is about one-sixth breast plus 1 in. Square down from 7½ and continue up into back scye; 7½ to 8¼ is ¾ to 1½ in. according to the closeness of the fit desired. 8¼ to M is 6 in. M to N, 1 to 2 in., according to the amount of spring desired.

Square down by 8¼ and N and add on ½ in. of round. Take out a fish under the arm of about 1 in.

When this is omitted reduce the back as per dot-and-dash line at P.

C to D, one-twelfth breast; D to E, the same quantity. Draw breast line from D through 21¾.

Make waist to measure, plus 3½ in.; add on 2 to 2½ in. in front of breast line and complete as shown. Drop fore part ¾ in. at J.

For double-breasted fronts add on 3½ in. in front of breast line and complete as per dot-and-dash line. Shape lapel at F G to taste.

Locate pockets as shown—ticket pocket on waist level and the front level with the front of hip pocket. Hip pocket 4 in. below waist. The centre of the pocket is X, and this is midway between side seam and breast line. Size of ticket pocket flap, 4 by 2; hip pocket flap, 7¼ by 2½.

The system for cutting the sleeve is the same as described for cutting the lounge jacket, but the measure from 2 to the depth of scye line must be measured to the true level of the bottom of the scye. The width at elbow and cuff must be increased by fully ½ in.

Waistcoats. Several of the measures taken for the coat are used also for the vest, with the addition of a measure taken from the back neck A [24] to the opening B and on to the full length C. The chest and waist measures illustrated in this figure at D and E are the same as for the coat. From the sectional measures taken for the coat we make these deductions. Front and over shoulder measures ¼ in., across chest ½ in.

THE BACK. Draw lines at right angles to 0 [23a]; 0 to 9, scye depth; 0 to 17, natural waist length; 17 to 1, 1 in.; draw line from 0.

From 1 mark in ¾ in., and draw back seam 0, ½ to ¾; 0 to 2½, one-twelfth breast less ½ in.; 2½ to ¾, ¾ in. Make ½ a pivot and sweep from

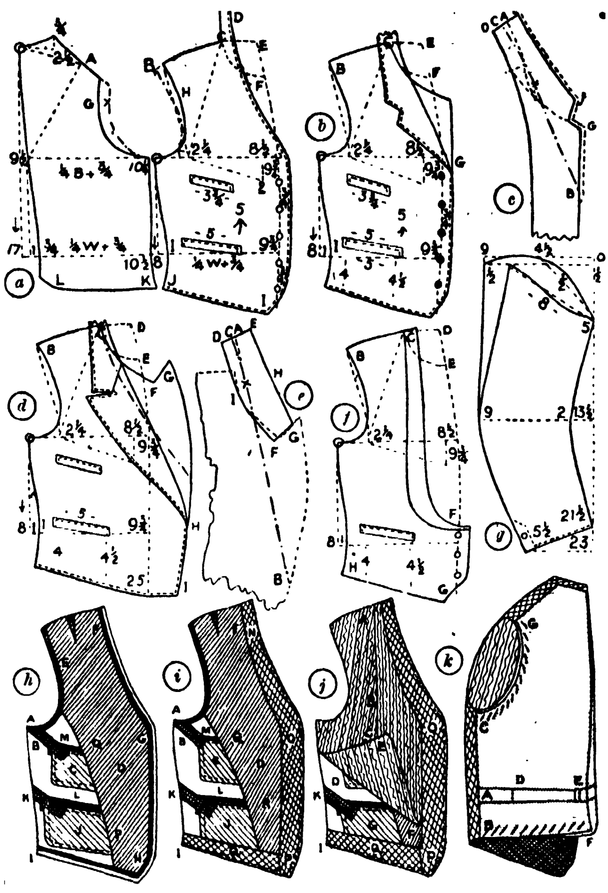
0 to A. Make width of shoulder one-eighth of breast plus ½ in.; ⅜ to 10¼ is ¼ of breast plus ¾ in.; ¾ to 10½ is ¼ of waist plus ¾ in.

Draw back scye and side seam, leaving the length of back to be adjusted after the fore part has been cut.

THE FORE PART. Draw lines at right angles to 0; 0 to 8, the distance between depth of scye and natural waist; 8 to 1, 1 in. for all sizes. Draw side seam. 0 to 9¾, ¼ of breast plus ¾ in.; 9¾ to 2¼, the width across chest (the ½ in. having been deducted as before stated); 2¼ to 8½, 5¾ in. (always); 8½ to 2, 2 in. (less for erect, more for stooping figures). Square by 2¼ and 2 up to C; 2¼ to C, the front shoulder measure less the width of back neck; 2¼ to B, the over-shoulder measure less ½ in., to A of the back, ¼ in. having been deducted from each; C to B a trifle less than back shoulder; C to E and C to F, one-twelfth of breast less ½ in.

Draw breast-line from E, through 9¾, to hollow. Shape scye from B to 0; 1 to 9¾ is ¼ of waist plus ¾ in. Add ¾ in. for button stand beyond 9¾.

Measure off the length to opening from C to breast-line, having first deducted the width of back neck. Continue on to I the full length, allowing ¾ in. for seams. Place one arm of the square on C, and the other on I, with the angle at side seam, and draw the run of the bottom of vest. Complete back length to harmonise with fore part.



23. WAISTCOATS

The style shown in this diagram is a "no collar vest," and for such the neck is filled up ¾ in. at C, which means that the stand of the collar is cut on to the neck. The pockets are placed on the level of waist about 5 by ¾ in., and are kept about 1 in. in front of the side seam. The watch pocket is put about 5 in. above the other, and is made about 3¾ by ¾ in. to slope up. The usual number of buttons placed up the front is six.

Step Collar Vest. The cutting of this fore part is identical with the preceding one, except at the neck, which has the neck cut down, as from C, to a little below F, the part above C being arranged in harmony with the shape of the lapel desired [23*b*].

THE COLLAR. B, ¼ in. above top buttonhole [23*c*]; X is ¾ in. up from hollow of gorge. Draw line from B through X to A. A to D, depth of fall; D to C, depth of stand; C to E, depth of fall. Length of collar, sufficient to go round the back neck. The facing and collar cover are usually cut in one piece, as indicated by dotted line E F G.

Double-breasted Vest. Similar to fore part of Diagram *b*, but with an extra amount added for overlap, as from 9¾ to H and 25 to I, adding, say, 2½ in. at H and 1¾ at I [23*d*]. Curve up the bottom slightly, as from 25 to I. Shape the lapel to taste at F G, or the neck may be cut down to the dot-and-dash line, and the upper part filled in with silesia. The collar for the double-breasted vest is shown on Diagram *e*, except that the shape at F G is different; that, however, is quite a matter of taste. B is ¼ in. above the top button; X to ¾ in. from I.

Draw line from B through X to A. A to D, depth of fall; D to C, depth of stand; C to E, depth of fall. Let collar overlap gorge ¼ in. at F, and let G touch the top of lapel.

Dress Vest. Similar to 23*a*, with the neck filled up as for "no collar." F is the opening mark back from breast-line 2½ to 3 in., and draw line up to ¾ in. front of C; fill in the corners ¾ in., and shape opening to taste [23*f*].

The collar for this is cut the same shape as the opening from C to F. The shape imparted at G is a matter of taste.

Sleeve Vests. Back and fore part as 23*a*, but with the shoulder made one-sixth of the breast, and the scye filled in as dot-and-dash line.

THE SLEEVE [23*g*]. Mark sleeve pitches; back, 2 in. down from shoulder point; front, $\frac{3}{4}$ in. up from bottom of scye. Draw lines at right angles to 0; 0 to $\frac{1}{2}$, $\frac{1}{2}$ in.; $\frac{1}{2}$ to 5, back pitch to depth of scye line.

0 to 9, size of top scye between the two pitches, with the shoulder seam put in a closing position. 0 to $4\frac{1}{2}$, half 0 to 9. Shape sleeve head as illustrated. Measure off length to elbow and cuff from 9 to 9 and $5\frac{1}{2}$. Hollow elbow 2 in. at forearm; make sleeve width of elbow one-sixth breast plus 1 in., and cuff one-sixth breast less $\frac{1}{2}$ in.; raise forearm at cuff $1\frac{1}{2}$ in. 5 to 8 is the size of the underscye between the two pitches. The undersleeve must not be "hollowed."

Making Up. The welt pockets are put in in the same manner as for a coat, the ends tacked to stays as shown at B and K of Diagram 23*h*. J shows the lower pocket, C the watch pocket, Q and P front tackings of the pockets through the canvas. D shows the canvas, and it will be noticed that a V of the same material has been inserted at the shoulder to impart form.

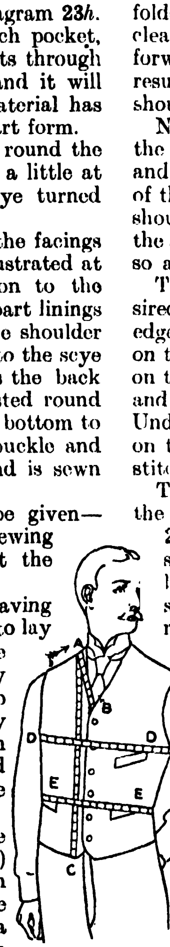
F G H I shows the stay tape put round the edges to steady it and to draw it in a little at G and H. E and A show the scye turned over.

Diagram 23*i* shows the next step, the facings being sewn on and turned over as illustrated at N O P Q. This is then seamed on to the canvas. Diagram 23*i* shows the fore part linings being put in; a fold is put down the shoulder at A, and the lining is then felled on to the scye and the facings. Diagram 23*k* shows the back sewn to the fore part. G to C is basted round on the outside, and B to F along the bottom to keep it in place for the press. The buckle and strap is put on at the waist level and is sewn in with the side seams.

The finishing touches may now be given—such as working the buttonholes, sewing on the buttons, and giving the vest the final pressing.

Cutting from the Cloth. Having cut out the patterns, the next step is to lay them down on the cloth so as to take them out of the cloth as economically as possible, and at the same time to arrange them in such a way that they will not be unduly biassed, whilst in the case of prominently checked materials it is necessary to arrange the corresponding seams to match.

First arrange the cloth with the way of the wool (if there is one) running from right to left, and then note if there is any string along the selvedge, as this usually indicates a damage and has to be avoided. Then arrange the various parts on the material, with due allowance for the necessary inlays. In Diagram 25 we show how to take a 36-in.-breast lounge suit out of $2\frac{3}{4}$ yd. of faced material, with all the usual inlays provided and very fair facings. This is practically self-explanatory if the student understands that F is the fly, V F the vest facing, T F the top flap, etc. 37 in. is reckoned to the yard, that being the universal standard adopted by woollen merchants.



24. VEST MEASUREMENTS

Trimmings. The following trimmings are required: $\frac{3}{4}$ yd. of canvas, $\frac{1}{2}$ yd. of silesia—to match—for pockets, striped sleeve lining to length of sleeve, 5 or 6 in. of linen, lining according to garment, buttons, twist, silk, coat-hanger, stay, tapes, etc. These are generally rolled up in the canvas and tied with the stay tape. The ticket containing the instructions to the workman is made out, and the garment handed over to be made up.

Hints on Making. The garment is usually unrolled and the ticket studied as a preliminary, the trimmings are checked off, and the marking threads put in, and then the shoulders are manipulated by the iron. The shoulder is folded over down the middle and moistened with clean water, and the iron worked backwards and forwards so as to form a hollow [25*i*]. This will result in stretching the gorge and the front of shoulder, and shrinking the hollow of the shoulder.

Now baste a strip of linen across the back of the pocket mouth, as shown in Diagram 25*f*, and later put another strip to go from the end of the pocket mouth into the side seam, as B. A should, of course, go on the straight, and B on the angle, the threads of the linen being arranged so as to provide the utmost support.

The flap is then cut to the size and shape desired, lined and stitched in the same style as the edges are stitched. Then place the flap down on the outside of the fore part, as F B [25*b*], and on the top of this put a piece of pocketing, as A, and then stitch through all the parts at A. Underneath a piece of pocketing has been seamed on to a narrow strip of cloth which, in turn, is stitched along the bottom of the pocket mouth.

The pocket mouth is then cut through between the two rows of stitching, as shown in Diagram 25*c*, and each of these is then turned in and stitched along the top. Diagram 25*d* shows the bottom jeating turned in and stitched, and 25*e* shows the flap. The pocket is then stitched round, and the stays are basted on [25*a*].

The canvas next claims attention, and, in order to get the best shape into this, "V's" are inserted at neck, shoulder, and scye [see W, 25*a*]. For these slits are made with the scissors at the most suitable parts, and then V's of canvas are inserted and opened out. The pocket ends may now be tacked. The edges are then steadied or drawn in a little with stay tape, and a piece of linen is put down each front to take the buttons and holes. A strip of linen is put along the crease row—this is known as a bridle, its object being to prevent stretching at that part. The lapel in front of this is padded to give it a nice curve, and the fronts are ready for their pressing, which should be done before the linings are put in.

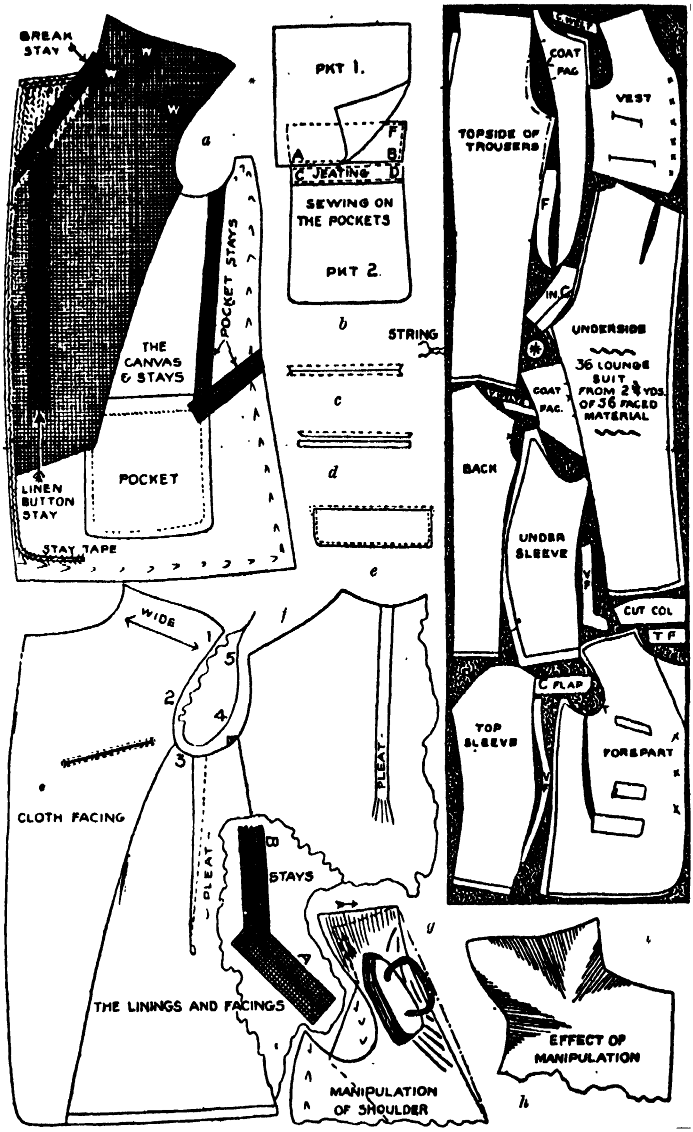
In putting in the linings, it is necessary to allow extra width to the facings across the shoulders, and to provide a pleat down the centre

of the back and under the arm, as marked in Diagram 25*f*. The facing on the turn must also be put on extra long and extra wide, so that it may lie smoothly when the lapel is turned back.

The shoulder seams are sewn, and the collar put on, keeping it fair across the back, long in the hollow of the gorge, and rather short in the front. The collar is made up on canvas, with the stand stitched and the fall padded to give it the proper curl. To get both ends of the collar alike, put a seam in the centre of back and cut the front ends where it joins the neck on the straight.

The outside collar is cut without a seam in the back; it is worked into shape by the iron, and put on long enough to cover the inside collar. The seams are usually drawn together. The edges are stitched, and in doing this it may be necessary to turn it at the start of the lapel.

In putting in the sleeves, the pitches must be first indicated; this is usually done at the time of cutting, but in case it should be omitted they should be located as follows: back, 2 in. below shoulder seam; front, ¾ in. up from scye level in front.



25. DETAILS OF CUTTING OUT AND MAKING

Putting in the Sleeve. Start fulness at 1 [25*f*], which is about 1 in. from shoulder seam, and continue it down to 2; from 2 to 3, plain; then put any fulness there may be in the under side at the bottom of scye 3; keep it rather tight in the neighbourhood of 4, and plain up to 5. The sleeve seam is then pressed open, the facing serged to it, and the sleeve lining felled. The remaining touches are pressing, buttonholing, buttoning, etc.—which we have already described—and the garment is finished. This gives the outline of making a lounge jacket, and the principle is similar for other garments.

When there is a waist seam, the fulness is started just in front of the under-arm seam and continued for about 3 or 4 in. in front. When silk facings are put on the fronts of frock or dress coats, it is usual to omit the cloth facing from the under part and merely put on a lining of domet, the facing only extending underneath the silk far enough to make a neat finish.

When garments are made up on the "sub-division" principle, they are usually fitted up with great care, and nearly every part is sewn by machine; thus the outside collar is sewn on to the facings and linings, the inside collar to the back and the fore part; then all is joined up round the edge, and, after the edges have been pared, it is turned out of the armhole.

The Production and Uses of Lead. The Romance of Aluminium. Antimony. Arsenic, Bismuth, Mercury, and Magnesium.

LEAD AND ALUMINIUM

THE important metals here dealt with are two of the most interesting. Aluminium has only had practical application, as a metal, in recent times, and is further peculiar in that it is produced industrially by processes quite outside the range of general metallurgical practice. Lead is one of the oldest metals in human use. Again, they represent the limits of weight among commercial metals. Lead is the heaviest and aluminium the lightest.

The lesser metals, used mainly for alloys, described here are antimony, arsenic, bismuth, mercury, and magnesium.

Lead is one of the oldest metals. As far back as 878 B.C. a king of Assyria took tribute in galena, and this ore was reduced by crude smelting operations centuries before that date. Lead used up to comparatively recent times was superior to the modern metal in colour and durability, owing to the presence of a small proportion of silver.

Properties of Lead. Lead, when pure, is a bluish-grey metal, and is soft, plastic, and viscous. It can be cut with a knife, and clean surfaces can be welded in the cold by pressure. It is almost non-elastic. A wire $\frac{1}{10}$th in. in diameter breaks under a strain of 30 lb. Lead met with in commerce is practically pure, owing in part to the rigid refining it undergoes for the recovery of the silver. It is the heaviest of the ordinary metals of commerce (S.G.=11·35).

According to Fizeau, its coefficient of expansion is 0·002948; its specific heat is 0·0314 (Regnault). It melts at 326° C., and contracts on solidifying. A film of oxide is rapidly formed in air, but increases very slowly. Pure water by itself is without action on lead, but if air be present a hydrated oxide is formed, which is soluble. Further, carbon dioxide, if present, makes this process of lead corrosion and solution a continuous one by precipitating the hydrate as carbonate as it is formed. There is, accordingly, danger in the use of lead pipes and tanks for the distribution of *pure* water; but, fortunately, drinking water is rarely chemically pure, and generally contains the small proportion of carbonate or sulphate of lime which suffices to prevent this action. Nitrates and nitrites increase it. Lead cisterns and domestic utensils of lead are, of course, highly dangerous. Dilute sulphuric acid is without action on lead, but when concentrated and heated it forms the sulphate. Dilute nitric acid readily dissolves lead.

Lead Ores. Lead occurs native, and mineralogists recognise some sixty ores, but, metallurgically, there are only three ores: (1) *Galena* (PbS), containing 86·6 per cent. of lead; (2) *Cerusite* ($PbCO_3$), 77·5 per cent.; and (3) *Anglesite* ($PbSO_4$), 68·3 per cent.

Galena is the principal lead ore. It is by far the most abundant, and is also the chief smelting mineral for silver, of which it contains from 0·01 to 0·3 per cent. as sulphide (= from 3 oz. to 113 oz. per ton). It contains from 83 to 86 per cent. of lead, and from 1·3 to 16 per cent. of sulphur. Galena occurs in a great many geological formations; its distribution is, in fact, almost universal. The principal mines of the world are those of the South of Spain and of Missouri, Utah, and Mississippi, in the United States. The galena mines of Broken Hill, New South Wales, and of Queensland are worked chiefly for their silver contents.

Anglesite and cerusite are generally found as surface deposits in galena mines, and are, in fact, atmospheric oxidation products of galena, as may be seen from their chemical composition—$PbO.SO_3$ and $PbO.CO_2$, anglesite being an intermediary stage in the production of the carbonate. The carbonate is sometimes found crystalline as cerusite, but more often occurs in earthy masses mixed with clay, limestone, iron oxide. The largest mines are those of Nevada and Colorado, in the United States of America, where the ore occurs in pockets in limestone. The sulphate (Anglesite, $PbSO_4$) is found in the United Kingdom, the United States, France, and Germany, but its distribution is limited. It is smelted with galena ores.

The arsenate (Mimetesite, $PbCl_2.3Pb_3As_2O_8$) is found in galena veins to a small extent in England and Saxony. Flint-glass makers use it. British lead and lead-silver ores (principally galena) are now mined only in Derbyshire, Flintshire, and the Isle of Man.

Treating the Ores. The treatment of galena is practically the treatment of lead ores in general. Separate processes for other ores are rarely used, and only on a much smaller scale. The carbonate and sulphate are forms of the sulphide which have been oxidised slowly by atmospheric agencies instead of rapidly in the furnace.

The principle of pure galena reduction is, perhaps, the simplest of all ore-reducing operations. It consists of roasting the sulphide until all the sulphur is oxidised, leaving the metallic lead. It is not quite so simple in operation, because galena ore is generally an admixture of lead sulphide with iron, copper, and zinc sulphides, zinc and lime carbonates, and siliceous substances. To concentrate the ore for smelting, these ingredients, which seriously affect the furnace treatment of the ore, are removed by "dressing." This consists of the operations of crushing in stamping mills and separating the particles according to their gravities, by washing in buddles, jiggers, or other separators.

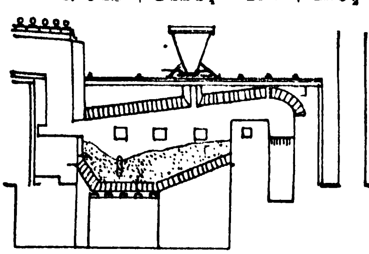
Lead ores are smelted in the reverberatory hearth, or blast furnaces. Practically none but galena ores with little silica can be treated in reverberatories, or low-silver ores on hearths, owing to volatilisation losses. Blast-furnace treatment is successful with all ores, but the lead produced is of lower grade than that resulting from reverberatory or hearth treatment, and these treatments are frequently combined with blast-furnace smelting. Wet processes do not exist commercially.

The principal type of lead reverberatories now used are the English, with its modification, the Silesian. In the English method, large furnaces, built on air-vaults or open underneath to cool the hearth, and high temperatures, are employed. A section of the furnace is shown in **3**. The sole is paved with slag from previous operations, and has a depression where the reduced metal collects and is tapped. The dressed ore is fed in through the hopper. The process consists in the oxidation of the ore by a series of calcinations and roastings, sulphur being eliminated as sulphurous acid, with the formation of lead oxide and sulphate, according to the equations:

1. $2PbS + 3O_2 = 2PbO + SO_2$
2. $PbS + 2O_2 = PbSO_4$

The temperature is then raised by closing dampers and furnace doors, and the oxide and sulphate react with unchanged sulphide, producing a regulus of lead, thus:

3. $PbS + 2PbO = 3Pb + SO_2$
4. $PbS + PbSO_4 = 2Pb + 2SO_2$

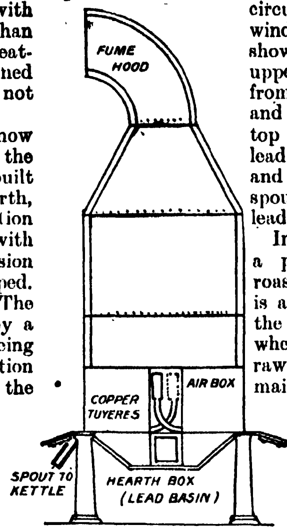


3. ENGLISH LEAD REVERBERATING FURNACE

These two operations of oxidation and reduction are repeated several times until the lead extraction is complete. Slaked lime is added to keep the charge from melting (reaction does not take place in fused ore). It also decomposes the sulphide. This is known as the *roast and reaction* method.

In the Silesian furnace a low temperature is used, giving a slag rich in lead (50 per cent.), which is smelted in the blast furnace. Volatilisation losses are thereby reduced, and a higher yield ultimately obtained.

The ore-hearth process resembles that of the reverberatory, with the difference that oxidation and reduction are simultaneous, the oxide and sulphate reacting with sulphide as soon as they are formed. In this process the ore is smelted in contact with the fuel by the action of a blast on the fuel, the principle being the same as that of the blacksmith's forge. The fuel consumption is about half that of a reverberatory, and the process is readily started and stopped, but the volatilisation losses are higher, and the process is of most value in places where labour is cheap and fuel dear, such as Mexico. Modern hearth-furnaces are water-jacketed, use hot blast, and produce large quantities of lead fume, which, when drawn off and filtered through woollen or cotton bags, form a good white paint, containing about 65 per cent. of lead sulphate, 26 per cent. of lead oxide, and 6 per cent. of zinc oxide. The Moffet hearth-furnace, one of the most modern, is shown in **4**. It consists of two hearths separated by a hollow partition, in the lower part of which water is circulated for cooling. The wind chest for the blast (not shown) is connected with the upper part of the partition, from which tuyeres descend and deliver the blast at the top of the hearth-box. The lead overflows from the hearth, and is delivered through a spout in the work-plate into a lead kettle.

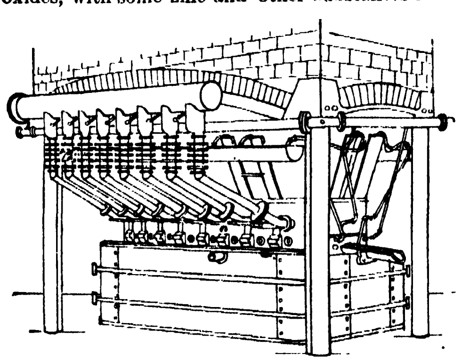


4 MOFFET DOUBLE-HEARTH FURNACE FOR LEAD

In blast-furnace treatment a preliminary reverberatory roasting, or "lime-roasting," is always carried out, unless the silver content is high, when the ore is smelted raw. The ore treated is then mainly oxide, with some sulphate and sulphide, as well as metallic constituents. The reaction is largely one of reduction of the oxide by the fuel (carbon) and the carbon monoxide produced by the action of the tuyeres' blast on the carbon, the heat of combination being sufficient to melt the slag and metal. The sulphate becomes sulphide, and, combining with copper, zinc, iron, and other metals present forms a matte, while silicates with any unreduced oxides form a fusible slag. Precipitation of the metal from the sulphide melt is also effected by the iron present.

A lead blast or shaft furnace has been shown [see **2**, page 270], and a modern rectangular furnace is given here [**5**].

Furnace Products. The principal smelting products are work-lead (base bullion), matte, flue-dust or fume. Flue-dust, or lead fume, is present in considerable quantities in furnace smoke, and to permit it to pass into the atmosphere would be a serious menace to the public health, besides causing loss to the smelter. It consists of a mixture of lead sulphides, sulphates, and oxides, with some zinc and other substances in the form of an infinitesimally fine dust. Condensation is effected by air or water cooling, the former requiring long flues. Formerly, it was accomplished by a mere lengthening of the flues, those at Freiberg,



5. RECTANGULAR BLAST FURNACE FOR LEAD

in Saxony, having been added to until they reached the extraordinary length of five miles. The fume is collected in settling chambers or in the bags already referred to. Besides being used as a natural paint, flue-dust is made into bricks with lime, and reduced in the furnace. It may be added as dust in small proportions to each furnace charge.

The sulphide mattes formed are granulated, re-roasted, and smelted in the blast furnace.

All the furnace processes produce lead in the form of work-lead, which contains the bulk of the silver and gold present in the one (if it be argentiferous), and also copper, arsenic, antimony, and iron as impurities. The latter metals render the lead hard and unsuitable for desilverising, and their removal is a preliminary necessity.

"Softening," or "improving," as it is called, which is the oxidation of these impurities in cast-iron kettles or reverberatory furnaces, is the next process, the liquated oxides being removed as a scum. Antimonial dross is worked up for Britannia, type, and other similar metals. If the lead be non-argentiferous (such as that produced from the ores of Missouri and part of Spain), this is practically all the refining that is necessary.

Desilverisation. Most lead is argentiferous, and recovery of the silver is an important part of the business of the lead-refiner. It is effected by cupellation [see page 1186], or by the Pattinson or Parkes alloy processes.

At one time the silver was recovered by cupellation alone, the whole of the lead being converted into oxide, which was reduced by re-smelting with carbon. This was costly, and very wasteful of lead, and direct cupellation is now used only in Mexico or parts of South America for very rich lead, where the silver is the only metal sought. Cupellation is, however, the final process in the separation of the silver from the alloys produced by the Pattinson and Parkes processes. Both these processes produce (1) marketable lead, and (2) a much smaller amount of a rich silver-lead or silver-zinc-lead alloy.

The Pattinson process depends upon the fact that silver in quantities up to 2¼ per cent. (700 oz. per ton) lowers the melting point of a lead-silver alloy, while larger proportions raise it. If molten argentiferous lead, therefore, be slowly cooled, the portion first crystallising out contains but little silver, the liquid portion being a eutectic alloy containing about three times as much of the metal. This crystallised lead can again be separated into two portions until lead, silver-free, and containing from 500 oz. to 600 oz. of silver per ton, is obtained. The Luce-Rozan modification of the process is now used. In it the formation of the crystals is promoted by blowing steam through the melt, thereby separating out impurities to the extent of ⅜ per cent., and the fluid eutectic alloy is tapped off, leaving the crystals behind, which are melted and cast for the market.

The Parkes process is based on the facts (1) that silver alloys more readily with zinc than with lead, and (2) that a silver-zinc alloy of lead is less fusible and lighter than lead, and is, therefore, separated from and floats on the surface of a lead melt. For this process it is essential that the zinc and lead should be practically pure. Molten lead from the "improving" furnace is tapped into cast-iron kettles holding about thirty tons, and a small amount of zinc stirred in. The crust which forms contains all the gold and copper present, with some silver. It is worked up separately to doré silver. The lead is now saturated with zinc, and on again adding zinc, most of the silver is collected in the crust. This is worked up to fine silver. A third addition of zinc reduces the silver to about 0·0003 per cent., the unsaturated crust being used in the second zincing of the next charge. The lead-zinc-silver alloy is liquated from the crusts in a reverberatory furnace, and the zinc recovered by distillation in a pear-shaped plumbago retort. The Parkes process is cheaper than the Pattinson (Rozan), but it does not remove bismuth, and the two processes may be combined for a base bullion containing appreciable amounts of bismuth.

Cupellation. The concentrated lead-silver alloys produced by these processes are finally separated by cupellation, the principles of which have already been explained [page 1186]. The English reverberatory furnace used for cupelling is oblong, and has a movable iron hearth, which is lined with a mixture of crushed limestone and clay, or Portland cement mixed with crushed firebrick. Bone-ash is no longer used. On a large scale, the smelting is made continuous by the addition of charge-lead until the charge contains from 60 per cent. to 80 per cent. of silver. Cupellation of the concentrated bullion from several furnaces is finished in a separate furnace, the silver being refined at the same time. The litharge produced may be sold as such or reduced to metallic lead. Refined and desilverised lead is not less than 99·98 per cent. pure.

Uses of Lead. Owing to its chemical inertness and great power of resisting corrosion by moisture and atmospheric agencies, lead is a valuable covering for roofs. It is extensively used for the same reasons, and because of its plasticity, in sheet form for gutters, ridges, and other building purposes of this nature, and for lining vats, tanks and chemical works' apparatus. Sheet lead is made by casting flat ingots in moulds holding several tons, and passing them several times through rolling mills until they weigh about 30 lb. to the square foot. It is cut into smaller sheets on the mill bed and rolled to the weights required for the market. Very thin sheets for tea-chest linings are made in the East by pressing molten lead between tiles faced with unsized paper. Tinned leadfoil is lead rolled and re-rolled between layers of tin to the thickness desired. Lead piping is made in an hydraulic press [see chapter on TUBE MANUFACTURE]. "Compo" pipe is lead piping hardened by alloying with antimony or tin. It is largely used in gasfitting. Large quantities of lead are also used for the plates of electric accumulators. In alloys and compounds lead has a very wide use.

Lead Alloys. The compositions of some of the pricipal alloys of lead are shown in the table on the next page.

Lead unites with most metals in all proportions. With tin it forms a valuable series of alloys of which the most important are the pewters and solders. Lead increases the malleability and ductibility of tin, but diminishes its tenacity and toughness. Pewter is now being replaced largely by unalloyed tin, which is whiter and safer for domestic purposes. The three grades of soft solder melt at 213° C., 210° C., and 206° C., respectively. "Plumbers' sealed solder," stamped by the Plumbers' Company, passes through a prolonged pasty stage as it cools, which is the state in which the plumber uses it in wiping a joint. It is due to the fact that the alloy has two points of solidification, one for the eutectic alloy contained, and another, much higher, for the excess of solid lead. The pasty mass, in fact, consists of a large proportion of

granular lead in a mother liquor of the fluid eutectic. Antifriction metals are very numerous, and the same name is given to many different formulæ. Fusible metals are largely used in safety devices actuated by sudden or excessive increase of temperature. The three given above melt below the boiling point of water. They are also used for taking casts of delicate objects.

Arsenic increases the fusibility of lead and also hardens it. In shot metal, which falls from a height into water, it enables the drops of metal to assume a spherical shape in falling. The perforations in the basin at the top of the shot-tower are regulated according to the size of the shot

COMPOSITION OF LEAD ALLOYS

Alloy.	Lead.	Tin.	Antimony.	Bismuth.	Copper.	Other Metals.
Pewter, common ..	20	80	—	—	—	—
„ good	14·25	85·75	—	—	—	—
„ best	—	99·5	—	—	0·5	—
Soft solder, common ..	50	50	—	—	—	—
„ „ coarse („ Plumbers' sealed ")	66·65	33·35	—	—	—	—
Soft solder, fine ..	33·35	66·65	—	—	—	—
Antifriction metals ..	55	40	5	—	—	—
„ „	85	—	10	5	—	—
Babbitt	40	45·5	13	—	1·5	—
Magnolia	78	6	16	—	—	—
Fusible metals:						
Newton's	31·25	18·75	—	50	—	—
Wood's	24	14	—	50	—	Cd 12
Lipowitz's	27	13	—	50	—	Cd 10
Shot-metal	99·1	—	—	—	—	As 0·9
Type-metal	83	—	17	—	—	—
Stereotype metal ..	69·3	—	15·35	15·35	—	—

required, and to prevent the drops of molten lead joining together in their fall, the holes are of irregular size, one being three times the diameter of the next and so on. In an American modification of the usual process, air is forced up a short tower at a high velocity so that the descending lead comes in contact with as much air as it would in a high tower. A centrifugal modification has also been introduced in which the metal is poured on a rapidly revolving disc from which it is thrown against a screen, in the form of drops.

Type metal is a lead alloy which has been made hard and expansible on cooling by the addition of antimony. Bismuth and tin increase its resistance to the crushing action of the press.

Lead Compounds. The most important compounds are white lead, a basic carbonate ($2PbCO_3.Pb(OH)_2$), litharge and massicot (PbO), and red lead, or minium (Pb_3O_4).

White lead is the most important of the lead compounds, and the most important of all pigments, forming the basis of nearly all ordinary paints. It possesses the greatest covering power and partially combines with oil, drying hard and homogeneous. It is, however, a very poisonous body, and is darkened by the action of sulphuretted hydrogen. Zinc white is its most important competitor, but it is deficient in covering power and dries slowly.

"Genuine" white lead is that prepared by the old Dutch method and consists of a spongy, transparent globular powder, the globules absorbing oil. Basic lead carbonate prepared otherwise is a dense crystalline powder, containing more carbonate and less hydrate, and the crystals do not absorb oil. In the Dutch method, lead, cast into the form of thin gratings, is stacked in brickwork chambers in layers on a bed of fermenting tan on which are placed earthenware pots containing a 3 per cent. solution of acetic acid. The stack is left for from 14 to 15 weeks. The fermenting tan supplies heat, to volatilise the acid solution, and also carbon dioxide to convert the coating of lead acetate formed on the plates into carbonate. This is detached, ground, washed, and dried, and the lead remaining used for the next corrosion. Many processes have been devised for producing the basic carbonate by less costly means, but none, so far, have succeeded in producing the amorphous compound. One which is largely used consists in treating very finely-divided lead in a rotating drum with acetic acid for seven days, air, fire-gases, and steam being blown in. The carbonate produced is ground and treated with soda in settling tanks. The best substitute, says Professor Church, is Freeman's white, which is a mixture of lead sulphate with zinc oxide and a little baryta. Others are lead sulphite, sulphates and carbonates of barium, strontium and calcium, or mixtures thereof with white lead.

Litharge and massicot are the saem oxide, but litharge is prepared above the melting point of the oxide and massicot below. The former is reddish yellow and crystalline, and the latter an amorphous lemon yellow powder. Litharge is used for the manufacture of other lead compounds of drying oils, oil varnishes, cements, for the lead plaster of pharmacy, and as a glaze for earthenware. Massicot is used for drying oils, as a pigment, in flint glass, and for the preparation of red lead.

Litharge is obtained either as the by-product of cupellation or by oxidation of the metal in a reverberatory furnace. If it be gradually cooled it partially flakes. It is sent to the market in the levigated form, produced by grinding, washing, and drying. It is also made direct from the ore. Massicot is prepared from the metal at a low heat on a reverberatory hearth.

Red lead, or minium, is prepared from yellow massicot (made by "drossing" lead) by heating it for 45 to 48 hours in a furnace known as the "colouring oven." Ground with linseed oil as a paint it forms a good protective covering for iron and other metal surfaces. It is also an ingredient in certain cements, and in flint glass.

ALUMINIUM

Aluminium, or aluminum, as it is frequently called in the United States, is one of the most interesting of the metals now in common use. Its history is not long, compared with the other useful metals, on account of the comparative rapidity of its development, but it is almost romantic, and every decade is packed with interest. Even now it is probably only in the infancy of its development, though whether that development will be in the metal or its alloys is yet to be seen.

Occurrence. Aluminium is more abundant throughout the world than any similar substance. It is the most widespread element, with the exception of oxygen and silicon (with which it is usually found in combination), and it is computed that it forms 8·16 per cent. of the earth's crust, the next most abundant metal (iron) amounting to 5·46 per cent.

There are four important natural compounds of aluminium—silicate, oxide, hydrated oxide, and fluoride.

All clays consist largely of aluminium *silicate*, and constitute the largest natural source of aluminium. The purest clay is kaolin, or china clay,

which consists almost entirely of aluminium disilicate ($Al_2O_3.2SiO_2.2H_2O$), of which large beds are found throughout the world, particularly Limoges, Devon, Cornwall, and the United States.

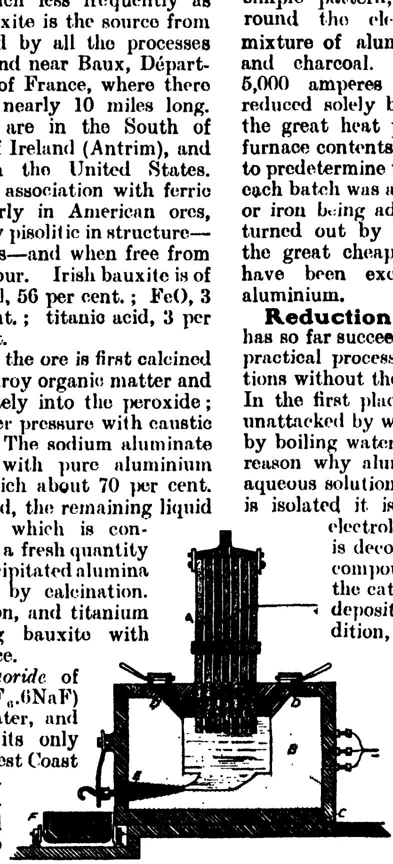
Kaolin contains 39·8 per cent. of alumina, and would thus seem to be the best ore, but since no satisfactory process for separating the alumina and the silica has been discovered, it is not available at present. If it were, nothing could compete with kaolin as an aluminium ore. Common clays are either impure kaolin or else contain a larger proportion of SiO_2, ranging up to 70 per cent.

The *anhydrous oxide* occurs as corundum and emery, and as gems—sapphire, ruby, etc. Corundum contains 52·9 per cent. of aluminium, the highest percentage of any ore. Large deposits occur in South India and the United States. It is not used as an ore, on account of its excessive hardness, which gives it more value as an abrasive.

Bauxite. The *hydrated oxide* (hydroxide) occurs largely and widely as bauxite (principally $Al_2O_3.2H_2O$), and also much less frequently as diaspore ($Al_2O_3.H_2O$). Bauxite is the source from which the metal is obtained by all the processes now in use. It was first found near Baux, Département de Var, in the South of France, where there are beds 36 ft. thick and nearly 10 miles long. The most important beds are in the South of France (Baux), the North of Ireland (Antrim), and Alabama and Georgia, in the United States. Bauxite is usually found in association with ferric oxide, silica, and, particularly in American ores, with titanic acid. It is usually pisolitic in structure—that is, in pea-like globules—and when free from iron is of a creamy white colour. Irish bauxite is of the average composition: Al, 56 per cent.; FeO, 3 per cent.; SiO_2, 12 per cent.; titanic acid, 3 per cent.; and H_2O, 26 per cent.

For electrolytic reduction, the ore is first calcined at a low temperature, to destroy organic matter and to convert the iron completely into the peroxide; then it is steam-heated under pressure with caustic soda solution, and filtered. The sodium aluminate thus produced is treated with pure aluminium hydroxide, by means of which about 70 per cent. of the alumina is precipitated, the remaining liquid being mainly caustic soda, which is concentrated, and used to treat a fresh quantity of calcined bauxite. The precipitated alumina is filtered and dehydrated by calcination. Reduction of the iron, silicon, and titanium is also effected by fusing bauxite with carbon in an electric furnace.

Cryolite is a double *fluoride* of aluminium and sodium ($Al_2F_6.6NaF$) with some ferric oxide, water, and other impurities. Almost its only source is Ivigtuk, on the West Coast of Greenland, and its consequent inaccessibility, combined with its general impurity, have caused it to be abandoned as an aluminium ore, though it was the basis of several of the older processes. The double fluoride is used as a solvent for alumina in modern electrolytic processes, but it is artificially prepared.



6. HEROULT ALUMINIUM FURNACE

a. Bundle of electrodes b. Carbon lining forming cathode c. Steel cell gates e. Tapping vent d. Alumina supply f. Receiving mould

The alums, which were the subject of the early investigation and from which the metal derives its title, include a number of double sulphates of aluminium and another metal (such as $K_2SO_4.Al_2(SO_4)_3.24H_2O$) containing much water of crystallisation. On calcination they give more or less pure alumina. They are of little practical interest in connection with the production of aluminium.

Electrothermic Reduction. No aluminium has been made by purely chemical methods for many years. The heat of combination of aluminium in forming the oxide (alumina) so greatly exceeds that of other common metals that the only feasible processes of reducing alumina by means of the ordinary reducing agents (carbon, etc.) are electrothermic. Electrical processes are of two kinds — *electrothermic* and *electrolytic*. Electrothermic processes are those in which the current acts merely as a heating agent, either by means of an arc or by the resistance of the substance treated. No purely electrothermic process is now used. The most successful was the Cowles, which produced, not aluminium, but alloys, principally aluminium bronze, in the days when the alloys were more valued than the pure metal. Rectangular fireclay furnaces of a quite simple pattern, with the molten charge packed round the electrodes, were charged with a mixture of alumina, or other ore, alloying metal and charcoal. A current of from 3,000 to 5,000 amperes was used, the alumina being reduced solely by the carbon of the electrodes in the great heat produced by the resistance of the furnace contents to the current. It was not possible to predetermine the composition of the alloys so that each batch was analysed and then re-melted, copper or iron being added as required. Much alloy was turned out by the Cowles Syndicate, but since the great cheapening of the pure metal, alloys have been exclusively made by melting with aluminium.

Reduction by Electrolysis. No one has so far succeeded in producing aluminium by any practical process of electrolysis from aqueous solutions without the use of soluble aluminium anodes. In the first place, although aluminium in mass is unattacked by water, yet the foil is rapidly oxidised by boiling water, and it is quite probable that the reason why aluminium is not easily deposited in aqueous solution is that, like sodium, as soon as it is isolated it is attacked. Further, in aqueous electrolysis of aluminous solutions water is decomposed, along with the aluminium compound, producing nascent hydrogen at the cathode. This causes the metal to be deposited in a finely-divided spongy condition, in which it readily attacks the water, being oxidised in the process. Electrolysis of fused alumina dissolved in a bath of cryolite (the double fluoride), kept molten by the heat due to the resistance offered by it to the passage of the current, is the principle of the processes now in use.

The details which follow concern the Héroult patents which are worked in England (by the British Aluminium Co.) and on the Continent. The Héroult furnace is shown in 6. Similar processes under the Hall patents are worked in the United States by the Pittsburgh Reduction Company.

The furnaces used are iron cells lined with carbon and rectangular in shape, the internal area being about 5 ft. by $2\frac{1}{2}$ ft. The negative pole of the dynamo is connected with a steel plate in the bottom of the cell or with the cell itself, in contact with which the

molten reduced aluminium acts, in practice, as the cathode. The anode is a bundle of carbon rods dipping into the electrolyte and capable of vertical adjustment.

The charge of cryolite is placed in the cell, and fused by the current. Pure powdered alumina is then fed in continuously while the operation proceeds. A current from 3 to 5 volts at a density of about 700 amperes per square foot, or 8,000 amperes per cell, is sufficient to maintain the temperature and the electrolysis. As part of the voltage is consumed in overcoming the resistance of the bath (thereby heating it), and as decomposition of cryolite theoretically requires 4 volts, the cryolite solvent is not attacked at all, if the bath be properly supplied with alumina. Therefore, except for mechanical losses, it lasts indefinitely and its impurities are not transmitted to the metal. Careful purification of the alumina and of the anode and lining carbon is all that is necessary to produce a pure metal. The result of the electrolysis is the splitting up of the alumina into aluminium (which, being slightly heavier in the molten state than the fused cryolite, sinks to the bottom of the cell, where it is run off) and oxgyen, which combines with the carbon of the anode to form carbon monoxide, the gas being burnt to dioxide outside the cell. The carbon consumed in this way is about equal in weight to the aluminium produced. The yield of metal in practice is ½ to ¾ lb. per 12 E.H.P. hours.

The advantage of combining internal heating with the electrolysis is that it enables the cells to be kept comparatively cool; if they were heated externally (as was proposed) they would have to be hotter than the electrolyte, and there is no suitable material that is able to withstand the action of nascent aluminium at high temperature.

Impurities. The principal impurities in reduced aluminium are silicon, carbon, iron, copper, lead and zinc. The last three, which, in very small proportions do not seriously affect the metal, and are not usually found, are partially removed by remelting. But no satisfactory methods of refining aluminium have yet been described. It can be purified absolutely by laboratory processes, but these are not industrially possible, and commercially, most of the impurities, particularly the important ones—silicon, carbon, and iron—are not removable. The metal has accordingly to be produced as pure as possible, and this is the reason why the alumina has to be so carefully purified. If refining were possible, aluminium could be reduced direct from bauxite, and so a considerable proportion of the expense of reduction would be saved. This remains to be accomplished.

Physical Properties. As in the case of iron, the physical properties of aluminium are considerably affected by the presence of small quantities of other constituents; but aluminium has not had, so far, the advantage of the comprehensive micrographic, physical and chemical research which has been bestowed on the varieties of iron, and much has yet to be learnt of the individual and collective influences of the minor ingredients of commercial aluminium. Silicon and iron are present to the extent of 1 per cent. in most commercial metal, and, in that proportion, slightly lessen its malleability. Two per cent. makes it brittle. Carbon in the smallest proportion markedly deteriorates it.

Pure aluminium is absolutely white on fracture. Commercial metal has a bluish tinge due to the presence of silicon, the tint deepening with the amount of impurities. Pure metal is distinctly softer than the commercial, but it is not so soft as pure tin. Drawing or rolling in the cold gives it nearly the hardness of brass.

The wonderful lightness of aluminium is its distinguishing economic feature. When pure, its specific gravity is 2·58 and 2·6 to 2·7 in the case of good commercial metal. The subjoined table demonstrates the advantage thus possessed by aluminium over other metals.

WEIGHT OF ALUMINIUM AND OTHER METALS

Metals.	Weight of Metals, Aluminium = 1.	Cubic in. per lb.
ALUMINIUM	1	11·2 to 10·65
Zinc	2·63 to 2·79	4·07 to 3·84
Iron, cast	2·79	3·84
Tin	2·8 to 2·9	3·79 to 3·56
Tin-plate	2·9 (about)	3·5 (about)
Iron, sheet and wrought	2·94 to 2·98	3·6 (about)
Steel	3·02 to 3·06	3·55 to 3·5
Iron, pure	3·04	3·54
Nickel	3·1 to 3·4	3·4
Brass (Cu 67%, Zn 33%)	3·2 to 3·29	3·33 to 3·25
Bronze (Cu 84%, Sn 16%)	3·25	3·29
German silver (20 %)	3·33 to 3·37	3·22 to 3·18
Copper	3·4	3·11
Silver	4·06	2·63
Lead	4·4	2·47
Gold	7·4	1·43
Platinum	8·3	1·28

The figures in the last column emphasise a fact which is liable to be overlooked. Metals are sold by weight. The capacity of a kettle is dependent on the volume of metal used. Its weight is merely a nuisance. Hence, since tin-plate is nearly three times as heavy as aluminium, the weight of metal which will make one tin kettle will make three aluminium kettles. Accordingly, whenever the cost of aluminium is less than three times that of tin-plate, aluminium is really cheaper. The relative costs in the following table will facilitate comparisons with other metals.

These figures are based on 1913 market prices. They can only be roughly approximate.

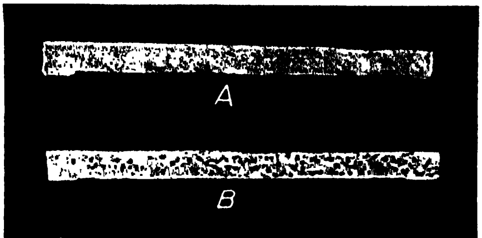
Aluminium melts at about 625° C., at a red heat and, at the temperature of the electric furnace, volatilises. Its mean specific heat is 0·2270, and its latent heat of fusion (that is, the amount of heat required to fuse it at the melting point) for 99·93 per cent. metal is 100 calories, which is more than that of any other useful metal. The consequence of the high value of these two factors is that aluminium melts very slowly even in a very hot fire, and that castings take several hours to cool. Its coefficient of linear expansion is 0·0000231 (Roberts-Austen) or 0·0000222 (Fizeau), which is only less than that of lead and zinc among the useful metals and about equal to tin. Its thermal conductivity is high and surpassed only by copper among the baser metals (Al = 31·33, Ag being 100, Cu 73·6, and steel 11·6).

COST OF ALUMINIUM AND OTHER METALS.

	Approximate manufacturing cost in pence per lb.	Approximate relative costs of equal masses.	Approximate costs of equal volumes.
ALUMINIUM	12	100	100
Tin	19	158	586
German silver	13	108	372
Copper	10	83	293
Bronze and brass	5	41	147
Zinc	4	33	92·3
Tin-plate	1·25	10·5	32
Steel	·6		15·5
Iron	·5		12·5

The relative electrical conductivity is put by Richards at 59 for 99 per cent. metal compared with copper 100 and iron 14 to 16. An aluminium wire that would carry the same current as a copper one would weigh only half as much. Aluminium is non-magnetic. It is very sonorous and is accordingly used for sounding boards.

Cast aluminium is not very elastic, but it becomes



7. SECTIONS OF STEEL CASTING
a. Improved by aluminium *b.* Without aluminium

stiffer, harder, and more rigid on working. Young's modulus for the castings is 11,000,000 lb., and 13,000,000 and 19,000,000 lb. for wire and rolled metal respectively.

The approximate tensile strength of commercial aluminium is exhibited in the following table, the relative strength of other metals (rolled) being included for the purpose of comparison.

It is important to note that the above figures for aluminium are reduced by 50 per cent. if the metal is heated over 100° C.

The relative figures show that, weight for weight, the only metals whose tensile strengths equal and exceed that of aluminium are cast steel and its own alloy, aluminium bronze. That is to say, for

RELATIVE STRENGTHS OF VARIOUS METALS

Metals.	Elastic limit in tons per sq. in.	Ultimate strength in tons per sq. in.	Relative strength for same weight.
ALUMINIUM, castings ..	3	7	—
" sheet ..	5·5	11	—
" wire ..	6·5	13 to 29	—
" rolled bars	7 to 13	12	100
Steel, cast	—	41	135
" soft	—	33	87
Aluminium bronze ..	—	40	118
Wrought iron	—	29	63
Brass, red	—	20	47
Bronze, gun	—	15	27
Copper	—	14	33

purposes where the requirements are strength and lightness, cast steel and aluminium bronze are the only competitors, expense being a secondary consideration.

Aluminium is a very malleable metal and can be rolled as easily as gold or silver. It can be beaten out into leaves of the thickness of $\frac{1}{40000}$th of an inch, and has superseded silver leaf for gilders' use. It is only less ductile than gold, silver, platinum, iron, and copper.

Chemical Properties. Aluminium is a trivalent atom of the relative weight 27, its equivalent being 9. Commercial aluminium on exposure becomes coated with a thin film of oxide, similar to that forming on zinc, which gives it a slightly dull appearance. This film thoroughly protects the surface from further oxidation.

The action of water has already been referred to. Sulphuretted hydrogen, which is responsible for the blackening and tarnishing of nearly all other metals, has no action on aluminium in the cold. It is but slightly attacked in the cold by sulphuric and nitric acids, but is dissolved readily in these acids when hot and concentrated, and also in cold concentrated hydrochloric acid.

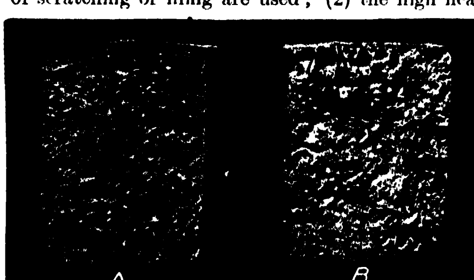
Potash and soda lye and alkalis in general also dissolve aluminium, forming the aluminate. Vinegar, organic acids, salt and food substances in general have very little action on the metal, even when boiling. There is no danger, in the case of culinary vessels, of such traces of aluminium compounds having any injurious action on the human body, for ordinary food contains much more than is so dissolved in cooking and the action is much less than in the case of copper, tin-plate, or iron. Food, particularly fruit, cooked in aluminium vessels is noticeably fresher and better flavoured than when cooked in other vessels.

Working the Metal. If not overheated, that is, much above its melting point, aluminium can be melted in ordinary plumbago crucibles without absorbing carbon or silicon. No flux is needed, nor is it advisable. Only a very thin film of oxide forms on the surface of molten metal, and this, while not spoiling castings, entirely prevents further oxidation. Molten aluminium is viscous and does not run sharply in moulds unless it is under pressure, which is supplied either by giving a head to the metal by means of gates and risers or by air-pressure in air-tight moulds. Sharp castings free from blow-holes are thus readily obtained, and hollow culinary ware as thin as $\frac{1}{16}$ in. is commonly cast. The shrinkage of castings is about 1·8 per cent. of the original volume, or nearly twice that of iron. The difficulty which this causes is also overcome by the use of gates and risers. In rolling or drawing aluminium frequent annealing is necessary, for the metal quickly hardens on working. It is best worked at temperatures betw 100° C. and 150° C.

The handsome "mat" or frosted effect which aluminium easily takes is obtained by dipping first in caustic soda or potash solution, then in strong nitric acid, finally washing with water.

Aluminium can be welded, but with difficulty, on account of its high specific heat and because of the soft "mushy" state which it assumes some time before melting.

Soldering. The difficulty of soldering aluminium has been recognised as an obstacle to its use since Deville first produced it commercially, and although innumerable formulæ and processes have been put forward, aluminium is not soldered if other means of uniting pieces of the metal are possible. There are three reasons for the difficulty: (1) the film of oxide which is always present prevents the solder getting to the metal and is not affected by ordinary fluxes and appears to form as quickly as it is removed, if the mechanical means of scratching or filing are used; (2) the high heat



8. STEEL CASTINGS
a. Section with aluminium *b.* Section without aluminium

conductivity of the metal renders local heating to alloying temperature a slow and difficult matter, increasingly so as the bulk of the article worked on increases, and causes the solder to chill quickly; (3) the highly electro-positive character of the metal causes galvanic action with low-temperature solders containing negative metals like lead, the result being disintegration at the joint. It cannot be said that these difficulties have yet been successfully overcome.

Alloys. Aluminium forms a large number of useful alloys. It unites easily with most of the metals, the combination being usually accompanied by a disengagement of heat. Lead and antimony appear to be the only metals not alloying with it easily. The practical production of these alloys from the metals is, in general, a very easy operation. The aluminium may be melted in a carbon or magnesia lined crucible, without a flux, and the other metal simply thrown in; it falls to the bottom, melts, and is absorbed by the aluminium.

Most of the alloys thus produced are improved by careful remelting, becoming more uniform, and finally perfectly so, by repeated fusions. Very few of the alloys liquate; in general the alloy acts as a single metal.

The useful alloys of aluminium fall into two groups: (1) aluminium containing 10 per cent. to 25 per cent. of other metals; (2) other metals containing 10 per cent. to 15 per cent. of aluminium. In almost every case, alloys between these limits possess no useful properties, and are mere chemical curiosities. Alloys of the first class are somewhat harder, stronger, and better wearing than the pure metal, while they retain its lightness. They do not, however, resist corrosion so well. In the case of the second class the effect seems to be a notable increase in strength and toughness and a remarkable change in the colour of the metals with high colours.

Aluminium Bronze. Of the alloys of the second class, and of all the aluminium alloys, aluminium bronze is the most important. These bronzes are made by adding 2·5, 5, 7·5, or 10 per cent. of pure aluminium to the purest copper (the smallest amounts of iron, antimony, or arsenic in the copper injuriously affect the alloy). They are metals having tensile strengths of from 20 tons to 40 tons per square inch as the percentage of aluminium rises, strengths not greatly inferior to that of the finest steel, which, moreover, are reduced by only one-fourth when the temperature rises to 300° C. These were the alloys made by the Cowley reduction process, but now they are exclusively made by adding the aluminium to molten copper. It is most probable that these alloys are chemical compounds, for after the aluminium has fused on addition to the copper, so much heat is evolved that the crucible becomes white-hot and has to be removed from the furnace, while the proportions of the constituents in the four principal alloys correspond with their formulæ. The alloys have considerable hardness (nearly equal to gun-steel), high elastic limits, and great extensibility under strain.

Aluminium bronze is not easily worked. It possesses many peculiarities. It can be well worked only within narrow limits of temperature; castings contract on cooling much more than in the case of aluminium, and the alloy can be forged only at a low red heat. It needs frequent annealing during working if worked cold.

The 2½ per cent. alloy resembles in colour gold of low carat alloyed with copper. The 5 per cent. more nearly approaches the colour of pure gold than any other metal; the 7 per cent. has the colour of jewellers' green gold; and the 10 per cent. is a bright light yellow.

The bronze alloys would be advantageous for most of the purposes for which brass or ordinary bronze is used, but as they cost considerably more they are used only where their particular excellence counterbalances the extra cost. Chief of these uses at present is the manufacture of propellers for which their strength, freedom from sea-water corrosion and galvanic action, well adapt them.

Various alloys with copper and zinc containing from 0·1 to 3·3 per cent. of aluminium are known as "aluminium brasses" and are considerably superior to ordinary brass in strength and power of resisting corrosion. They are cheaper than the bronze alloys and can be forged at a red heat.

Metallurgical Uses. The widest and most important use of aluminium is probably still in the purification and improvement of iron and steel, and the castings thereof. For this purpose it is always added as "ferro-aluminium," an alloy obtained by adding from 5 per cent. to 15 per cent. of aluminium to pure pig iron. Added to low carbon steel up to 0·2 per cent. it increases elastic limit and tensile strength (at the expense of ductility) and gives good castings without blowholes.

Its value in this connection is illustrated by the photographs of steel castings reproduced in **7** and **8**. In both cases A is the same metal as B, but has had aluminium added to it before casting, 0·1 per cent. in the case of **7**, and 0·5 per cent. in the other case, illustrated in **8**.

By adding from 0·05 per cent. to 0·1 per cent. of aluminium to molten wrought iron a very fluid melt is obtained without the superheating which is ordinarily necessary to cast wrought iron. Castings so produced are called "mitis" castings. They are tougher than malleable iron castings, though not quite so uniform, and are almost entirely free from blowholes. In fact, mitis castings are objects cast in low-carbon steel, yet having all desirable properties of wrought iron. None of the added aluminium remains in the casting. Its office is simply that of reducing the skin of oxide which prevents the wrought iron from becoming fluid, and of preventing the formation of blowholes by keeping the metal fluid long enough to enable all the occluded and dissolved gases to escape.

In the case of cast iron somewhat similar results are produced, but for different reasons. Most of the aluminium remains in the finished product because there is no oxide to reduce, its presence being prevented by the considerable quantities of carbon present. The fluidity of the melt is hardly affected. The practical results are that cleaner, more solid, softer castings are obtained with a considerable deduction in the percentage of defective castings.

Non-technical Uses. Of these the largest at present is probably as culinary utensils, where its lightness, toughness, non-poisonous, non-rusting, and hard-wearing properties would, but for its cost, have long ago given it that supremacy which is a mere matter of time. An important property in this connection is its high heat-conductivity, which makes cooking in aluminium vessels a speedy matter and scorching almost impossible.

Great hopes were raised at first of the use of aluminium in building and general construction, but the great depreciation in strength which it suffers as the temperature rises definitely put it out of this field.

Aluminium for electrical conductors has been rejected by the British Post Office because of the

difficulty of making joints, the indefinite and permanent elongation, and, in the case of the bronze, of deterioration. Its low melting point renders the danger of its fusing considerable if the current it is carrying be much increased. It is, however, used for power conductors in the United States. Whenever it is less than twice the price of copper it is, for conductors, relatively cheaper.

It is successfully used in lithography in place of the heavy, fragile, scarce, and variable Solenhofen stone. Its use renders quick printing on rotary machines possible.

Its incorrodibility and innocuousness render it of considerable use in surgery and dental mechanics. It is considerably used in scientific instruments, particularly where the inertia of a heavy moving part has to be avoided. Owing to its comparative freedom from chemical action it is used in many forms of chemical apparatus.

In the form of powder it makes an excellent flashlight, for, in the finely divided form, aluminium burns very readily. The powder is also used with ferric oxide, as "thermit," in the Goldschmidt process, for reducing refractory metallic oxides, and for welding rails, etc.

Aluminium is also largely used in motor-car building, in petrol motor-engines, in aeronautic apparatus and machines, and in a host of smaller miscellaneous articles of everyday use, besides the particular uses referred to above, either for its lightness or its decorative effects. In general it is being increasingly used wherever lightness is synonymous with economy.

Aluminium Salts. Alum and the aluminates are much used in the industries. Alum, in commerce, is the term applied to a double sulphate of aluminium with a base such as potassium, sodium, or ammonium. Aluminium salts are the chief mordants used in textile dyeing to fix the dyestuff in the fibre and to modify the colour or shade. Alum is being displaced by the pure sulphate, from which all other aluminium mordants are prepared.

When solutions of basic aluminium sulphates are boiled, a still more basic and insoluble salt is thrown down, especially in the presence of textile fibres. The basic acetates and sulpho-acetates ("red mordants") are used in cotton printing.

Aluminium sulphates are used for the base in "lake" pigments, and are added to Prussian blue and other colours to improve the painting quality. They are also used in the tawing processes of preparing skins for boot and glove making, and in preparing glue for paper-glazing.

In plaster-making, alum is used to increase the hardness. Heated plaster is plunged in an 8 per cent. solution and calcined. When mixed with water, alumed plasters set more slowly but much harder than ordinary plasters, the hardness resembling that of marble.

Antimony. The chief ore of antimony is stibnite (Sb_2S_3). This sulphide may be largely separated from the rock in which it occurs by liquation. This is done on the concave hearth of a reverberatory furnace, which is lined with charcoal to prevent oxidation. Antimony was formerly called *regulus of antimony*, and in this country is extracted by reduction in crucibles by iron. The metal is purified by fusion with nitre, or by melting and stirring with an iron rod.

Antimony is a bluish-white metal, highly crystalline and brittle, with a specific gravity of 6·7. The surface of the cast metal shows characteristic fern-like markings. It expands on solidifying, and imparts this property to many of its alloys. It melts at 632° C. It does not oxidise in air at ordinary temperatures, but, when heated, unites with oxygen to form the white oxide, Sb_2O_3.

Antimony is too brittle to be used alone for most purposes, but it is of great service as a constituent of certain alloys. It is used to harden lead and tin. It is very valuable in type metal, imparting the property of expansion so necessary for obtaining a sharp and well-defined impression of the letters when printing.

Arsenic. Arsenic is a brittle metal of a steel-grey colour and metallic lustre. Its specific gravity is 5·7. It is a poor conductor of heat and electricity, and in the pure state is without taste or odour. It is very volatile, and burns in air with the formation of the white oxide, As_2O_3. It is a constituent of shot metal and other alloys. It is a valuable bronzing agent. The ores are sulphides, but it occurs chiefly in ores of other metals, such as those of nickel and cobalt. It is extracted from its ores in retorts, from which, on being heated, the arsenic sublimes and is collected.

Bismuth. Bismuth is a comparatively rare metal, associated chiefly with ores of nickel, copper, and silver, from which the crude metal is separated by liquation, or smelted by roasting and reduction in crucibles with iron and carbon. The raw metal is refined with nitre. Bismuth is a reddish-white metal, highly crystalline and brittle. Its low melting point and its property of expanding during solidification make it useful as a constituent of certain alloys, such as fine solder and type metal. It melts at 268° C., its specific gravity is 9·8 in the solid and 10 in the liquid state. It burns in air with a bluish-white flame, forming bismuth oxide (Bi_2O_3). Bismuth, like lead, may be used as a solvent metal in the process of cupellation. It is used in the construction of thermo-piles, in fusible alloys, and in some kinds of type and stereotyper's metal.

Mercury. Mercury, or quicksilver, occurs in Nature in the metallic state and in *cinnabar* (HgS). The metal is extracted from its ores by a distillation method. The ore is heated in a special furnace, and the vapours of mercury condensed in condensing chambers. The crude metal may contain lead, bismuth, zinc, cadmium, and other impurities. It is purified by covering the metal with dilute nitric acid, and allowing it to stand some time; the acid gradually dissolves out the base metals, together with some mercury. It is finally redistilled, and is thus made practically pure.

Mercury is a silver-white metal, liquid at ordinary temperatures, and boils at 360° C. Its specific gravity is 13·6. It is not affected by air or oxygen at ordinary temperatures, but if any discoloration occurs on shaking it in a bottle it indicates that impurities are present. It is used somewhat in gilding, but chiefly in the extraction of gold and silver, and in the construction of thermometers, barometers, etc. In dentistry, mercury is a constituent of dentists' preparations and alloys.

Magnesium. Magnesium is a metal very similar to aluminium, but whiter and lighter, its specific gravity being only 1·74. It melts at 750° C., and boils at about 1100° C. It is rather more oxidisable than zinc. It is best worked at a temperature of 450° C. Magnesium wire is made by forcing the heated metal through holes in a steel plate, and magnesium ribbon is made by passing the metal between heated rolls. It is used in the refining of some metals, owing to its great affinity for oxygen and other non-metals. It is a constituent of some alloys, such as magnalium.

Profit and Loss. Subsidiary and Drawings Accounts. Expenses of Production and Distribution. Ranking Assets and Liabilities. Depreciation.

THE BALANCE SHEET

THE totals of the trial balance having been found to agree, the work of closing the books may now proceed. The object of our trader in preparing his final accounts is, as we have seen, to ascertain the nature and extent of his gains and losses, assets and liabilities. It should be observed that it is almost as important for a trader to know the nature of his gains and losses as to know their extent, for a knowledge of the manner in which they arise will enable him to push business in a direction where he finds he is already making good profits, or, on the other hand, to curtail expenses under heads which are not repaying the outlay upon them.

Division of Profit and Loss Account. It is largely for this reason that the profit and loss account has to-day so many divisions. It is not sufficient to know that although the gross profit of a business is £1000, the net profit, after deducting an item described as "Sundry Trade Expenses," is £300 only. The modern business man wants further information. How is the difference of £700 made up? "Sundry Trade Expenses" may mean anything. The item may, and probably does, contain salaries, rent, rates and taxes, discounts allowed, gas, office cleaning, and the thousand-and-one petty items that go to swell the expenses of carrying on an office or warehouse. But let us know what they are, so that we can, if desirable, cut down expenditure in one direction and add to it in another, with a view to increasing the effectiveness of the outlay.

Heads of Expenditure. The heads over which the expenses are spread depend very largely upon the nature of the business, but some items are common to nearly all trading concerns. Salaries, rent, rates, taxes, lighting and heating, have to be paid in nearly every establishment. Other items, such as insurance, advertising, printing, discounts and commissions, are not so common, but are yet very frequently incurred. A close scrutiny of these items should enable a trader to form a conclusion whether his expenditure under a particular head is justified or not, having regard to the size of his business and the amount of his turnover. He may find that the amount he is paying for his rent, or for the salaries of his employees, is altogether out of proportion to his other expenses, and is practically swallowing all his profits. He must either reduce this expenditure if his sales are stationary, or increase the latter if he is to continue his expenditure at the same rate. On the other hand, he may find that a judicious outlay of £100 in advertising has caused an increase of £500 in his sales. This would probably lead him to conclude that further expenditure in this direction would result in extending his business, and he would extend his advertising campaign accordingly.

In the case of traders, as a rule the only item on the revenue side of the profit and loss account is the gross profit brought down from the trading account, arising from the sale of the goods. No analysis, therefore, is required for this side. In businesses where the revenue is of a miscellaneous nature, appropriate accounts are opened as in the case of expenses.

Method of Analysing. Enough has been said to show the necessity of analysing the expenses of the business in such a way that the proprietor can put his finger on a weak spot in his outgoings, or, on the other hand, satisfy himself that the expenditure is on an economical basis and allocated in such a manner as to produce the best results. But it is not necessary to wait until the profit and loss account has been completed before making the analysis. It can be made as the work of writing up the books proceeds throughout the year. In the case of the goods account it was seen to be desirable to have not one, but several, accounts to record our purchases and sales, and other matters directly connected with the buying or finishing of the goods. So, in the case of the profit and loss account, several sub-accounts are opened; and as sums are paid for expenses the payments are posted from the credit side of the cash book to the debit of the appropriate accounts opened in the ledger. The result will be that at the end of the financial year, instead of one large miscellaneous account containing expenses of all kinds, we shall have many smaller accounts, each devoted to an expense of a particular kind. The number of such accounts depends upon the size of the business, but a reference to the trial balance on page 1327 carries conviction of the superiority of this method of analysing the expenses rather than including them in one account under a general title.

Closing Subsidiary Accounts. In order to arrive at the amount of profit or loss as a whole, each item in the trial balance which records revenue or expenditure in carrying on the business must now be brought into a general profit and loss account. This must obviously be done, for the usefulness of the whole work will be destroyed if the accounts are not focussed in such a way as to give the trader a bird's-eye view of the items making up the profit or loss for the year. There is now no objection to the various heads of expenditure being included in one account, for they will not now consist of hundreds of small items in no kind of order, covering many pages of the ledger, but

of some twenty items at most, being the balances of the various sub-accounts already explained.

Those accounts are now closed by the balances being transferred to the profit and loss account by means of a journal entry debiting that account and crediting each sub-account of expenditure with the balance shown thereon. In the event of there being any source of revenue other than the sales, the accounts which have been credited by such revenue will be closed into the profit and loss account by a transfer of the balance being passed through the journal debiting the account and crediting profit and loss account.

Applying these principles to the trial balance on page 1327, and assuming the stock on hand to be worth £2,500, we should obtain the following as our trading and profit and loss account of the business of Smith & Jones:

Again, in a business part of an item of the same general character may be included in trading, and the rest in profit and loss. For example, the wages of the workmen would be a part of the cost of the finished goods, while the remuneration of the travellers and clerks would not. The wages would be charged to trading account, the remuneration to profit and loss account. The general principle to be observed is that cost of production is included in the first part of the trading and profit and loss account, while expenses of distribution come into the second part.

Disposal of Profit or Loss. The balance of profit or loss is not left on the account and brought down as the amount with which to begin the new trading period; that course is only adopted with the real and personal accounts. The profits of a business belong to

Dr. TRADING AND PROFIT AND LOSS ACCOUNT Cr.

To Stock		1,750 0 0	By Sales	6,700 0 0	
,, Purchases ..	5,250 0 0		*Less* Returns Inwards	152 10 0	6,547 10 0
Less Returns Outwards	105 15 0	5,144 5 0	,, Stock on hand..		2,500 0 0
,, Wages		725 16 0			
,, Freight and Carriage		146 8 6			
,, Gross Profit carried down ..		1,281 0 6			
		9,047 10 0			9,047 10 0
To Salaries		357 10 0	By Gross Profit, b/d		1,281 0 6
,, Rent, Rates and Taxes ..		350 0 0			
,, Discounts ..		23 1 3			
,, Miscellaneous Trade Expenses.		109 16 2			
,, Balance, being Net Profit ..		440 13 1			
		£1,281 0 6			£1,281 0 6

It will be observed that the gross amount of the purchases and sales are stated in an inner column in which the returns are also entered and then deducted, the net amount of goods bought and sold being extended to the outer column. This is found to be convenient in practice, as affording at a glance the actual amount of purchases and sales for the year.

Production and Distribution. A question sometimes arises whether a particular item of expenditure should be charged to the trading or to the profit and loss account. The decision will to some extent depend upon the character of the business, for items which in one case would be debited to the trading account would in another case be charged to the profit and loss section. For instance, in an ironfounder's business coal would be largely used in producing the finished article, and would be part of the cost thereof. In that case the outlay on coals would be charged to trading account, while in the case of a business where coal is only used for ordinary heating purposes it would be charged to profit and loss, as the expenditure forms no part of the cost of the goods sold.

the proprietor, or, if there be more than one, to the partners in the concern, and the balance of profit as shown by the account must be transferred to their accounts by means of a journal entry debiting profit and loss, and crediting them. The proportion to be credited to each partner depends upon the terms of the agreement between them as to sharing profits and losses. This agreement contains many provisions besides that dealing with this point, and will be explained at greater length when the question of partnership accounts as a whole is receiving consideration.

It should be mentioned here, however, that the amounts are not carried direct to the credit of the partners on their capital accounts, but are taken to their respective *drawings accounts.* These are accounts opened in the name of each partner for the purpose of recording amounts drawn by them from the business during the year on account of their shares of profits, which, of course, are not definitely known until the final accounts are made up. The drawings are usually in the form of cash, the payments being recorded in the cash book and posted to the debit of the accounts as the money is drawn.

If, as sometimes happens, a partner has goods from the business for his private use, he is charged with the price in the same way as an ordinary customer, the amount being posted from the day book to the debit of his drawings account.

Closing the Drawings Accounts. When the books are closed at the end of the firm's financial year, the balances of the drawings accounts are transferred by journal entries to the credit of the several partners' capital accounts. In the particular case with which we are dealing we will assume that the partners jointly manage the business, and, their capitals being the same, the profits or losses are shared equally. They will therefore be entitled to £220 6s. 6½d. each, but, as fractions of a penny are not regarded in accounts of this nature, a journal entry will be made, debiting profit and loss account, and crediting Smith's drawing account with £220 6s. 7d. A similar entry will be passed crediting Jones's drawing account with £220 6s. 6d. Their drawing accounts will thus show balances of £70 6s. 7d. and £70 6s. 6d., and these will be transferred to their respective capital accounts, increasing the credit balances thereof by the amounts so transferred. The accounts are variously styled drawing, private, or current accounts in different businesses, but by whichever name they are known they contain in every case particulars of the same nature and are dealt with as described. Any overdrawing of his ascertained share of profit by a partner will be carried to the debit of the partner's capital account, thus reducing the amount of his capital; but it is not unusual for a partner to pay into the business any excess of this nature, so that his capital account shall not be disturbed.

The Balance Sheet. Having now dealt with those accounts in the trial balance affecting profit and loss, and transferred the balance ascertained (being the net profit) to the partners' accounts, we proceed to dispose of the remaining accounts. Upon examination these will be found to consist of property belonging to the business, including debts owing by customers, or of amounts owing by the business; in other words, of assets and liabilities. These have now to be arranged in the form of a statement in such a manner that the partners can see at a glance what is the nature and extent of the assets and liabilities.

The method by which this is effected is by dividing the statement into two parts, one for assets, the other for liabilities. But before making up the statement—or, as it is called, the balance sheet—it is necessary to balance the accounts in the ledger from which it is compiled. This is done by writing in the amount of the balance on each account on the smaller side, then totalling and ruling off the account and carrying down the balance to the opposite side from that on which it was first entered. No journal entries need be made for these items, as they do not consist of transfers from one account to another. Those accounts which have the same amounts entered on each side without the inclusion of a balancing entry are ruled off, and the totals inserted. Having taken this necessary step, we can now construct our final balance sheet, thus:

BALANCE SHEET, 31st DECEMBER, 1905.

Liabilities.			Assets		
Sundry Creditors:			Cash at Bank ..	414 3 2	
F. White	205 12 10		do. in hand ..	12 18 6	
					427 1 8
S. Grey	164 9 11		Sundry Debtors:		
		370 2 9	A. Black	200 19 6	
			G. Brown ..	196 11 7	
Capital Accounts:			W. Green ..	186 3 1	
Smith	1,570 6 7				583 14 2
Jones	1,570 6 6	3,140 13 1	Stock of goods on hand		2,500 0 0
		3,510 15 10			3,510 15 10

The difference between the assets and the liabilities to outside creditors must always equal the balances of the proprietors' capital accounts.

Grouping of Accounts. The first thing to be noticed in connection with this balance sheet is that items of a similar nature are first entered in an inner column, and their total extended to an outer column. This is to enable the proprietor of a business to see at once the amount of his property of a particular description or the extent of his liabilities under a certain head. In the specimen given the only classes of accounts, besides the capital accounts, in which there is more than one item, are the sundry debtors and creditors; but in some businesses the main classes of assets and liabilities are subdivided under several heads, and this renders it necessary to group the various items under their proper headings in the balance sheet, in order that a correct idea of the nature of the property and liabilities may be formed. This feature of the balance sheet is obvious to the most casual observer, but there is a further point which would not be so apparent to a person unfamiliar with such documents and the principles of their construction—that is, the order in which the accounts are set out.

Ranking the Assets. This is an observance of the principle that the accounts should enable the trader to ascertain not only the extent, but also the nature, of his assets and liabilities. The order in which the assets should be ranked is well settled on broad lines, but in some businesses there are classes of assets practically on the same level as one another,

and as to which there may be legitimate difference of opinion regarding their order of priority. These are, however, unimportant. The guiding principle to be observed is that the assets should be ranked in the order in which they are most readily available for realisation. Following this rule, the assets should be arranged in the following order:

1. Cash. In many businesses this appears in various forms: (*a*) cash at bank on ordinary current account—*i.e.*, paid in and drawn upon by cheque daily; (*b*) general cash (if any) in the office; (*c*) petty cash in the hands of the petty cash officer; (*d*) cash at bank on deposit in respect of which it may be necessary to give the bank notice of withdrawal before it can be obtained.

2. Investments belonging to the business. In trading concerns it is not often that the cash capital is used for the purpose of buying securities. It can be more profitably employed in the purchase of goods of the description sold by the business. If, however, there should be any investments, it is desirable to specify them.

3. Sundry debtors. These are frequently divided into two classes—those who have given bills for the amount of their indebtedness, and those who have not. The former appear under the head of bills receivable; the latter under sundry debtors on open accounts, which are those showing a balance due for which the business has received no payment of any kind. The totals of the two classes appear first in the inner column, and are then extended into the outer column as one item.

4. The stocks of goods belonging to the business. These will consist of the stock actually on the premises, and of any items that may be in the hands of other persons, either for sale on commission (consignments) or on approval.

5. Movable property of a less easily realisable nature than those given above, consisting of (*a*) plant and machinery; (*b*) horses, carts, and motor vehicles; (*c*) fixtures, fittings, and furniture; (*d*) patent rights.

6. Immovable property—including (*a*) freehold land and buildings, and (*b*) leasehold premises.

7. Goodwill.

Ranking the Liabilities. On the other side of the balance sheet also it is necessary to have a systematic arrangement of the items. There are liabilities of various kinds, and the order to be observed in arranging them is, in an ordinary business, as under:

1. Any liabilities for which security has been given, such as mortgages or an over-draft at the bank.

2. Sundry trade creditors, distinguishing between those who hold bills payable and those on open accounts.

3. Any reserve accounts which may have been created. (These will be explained later.)

4. The capital accounts of the proprietors.

The rule to be followed in arranging the liabilities is to state first those to persons outside the business, and then other liabilities, such as that of the business to the proprietor for the amount of his capital.

Floating Assets. The assets set out above may be divided into two classes:

(1) Those constantly changing in character.
(2) Those which do not so change, but remain in the same condition throughout (subject to wear and tear).

The first four items will be included in class 1, and are known as floating assets. A study of the items will, in a measure, explain this description. The cash, debts, and stock are constantly changing hands, while their value is continually fluctuating as between themselves, and, if the business is successful, also increasing. That they change in character and increase in amount will be evident if we consider the various steps in connection with a purchase of goods.

An order for goods is given by our trader. The goods arrive and are taken into stock, thereby increasing that item. They are then paid for, the result being a diminution of the bank balance. In course of time they are sold, thus reducing the stock and increasing the book debts. Subsequently the debtor may discharge his liability by giving a bill, thereby adding to the value of bills receivable and reducing the open book debts. Later, the bill is met at maturity, and increases the bank balance. The net result should be an augmentation of the cash in the bank, for naturally our trader will not have sold the goods for less than he gave for them.

Fixed Assets. The remaining assets, on the other hand, may be said to be permanent. They are used over and over again in the making or handling of the goods. In an ordinary trading concern the premises, plant, machinery, fixtures and furniture are used daily in carrying on the business, which, indeed, could not be continued without them. A manufacturer uses his machinery—his fixed asset—to transform his raw material—his floating asset—into the finished article. And this not once, but many times. The machinery has not changed in form in any way, but the transformation of the raw material into the finished piece is another illustration of the manner in which the floating assets change in character and value, for the manufactured goods will naturally be worth more than the raw material of which they are made. To summarise the matter, it may be said that the fixed assets are those which are continually used to earn income for the proprietor.

It should be noticed that an item which in one business is a fixed asset, may in another be ranked as a floating asset. For instance, machinery employed in a printing establishment would be a fixed asset, while in the case of a maker of machinery it would be part of his stock, and therefore one of his floating assets.

Depreciation of Assets. A passing reference has been made to wear and tear of the fixed assets, and mention has also been made of the depreciation of the stock of goods in the hands of a trader. These are matters which engage the serious attention of the accountant when preparing the final accounts, for unless

due allowance is made under these heads before determining what is the net profit of a business, the result obtained is misleading and may involve grave consequences. Practically every asset of a business, with the exception of cash, is subject to depreciation of one kind or another. The rate or amount is not, however, by any means fixed.

The depreciation of stock-in-trade has received some consideration, and it will be sufficient to state that as a general rule stock should fall very little in value.

Wastage of Fixed Assets. It is chiefly in connection with assets of a permanent nature that care has to be taken to make proper provision for decrease in value. In a manufacturing business, for example, the wear and tear of the machinery is as much a part of the cost of the manufactured articles as is the cost of the raw materials and the labour put into them. The measure of the cost under this head is the difference between the price of the machine and its present value. The latter could only be ascertained by calling in an expert to make a valuation. This is not found convenient in practice, besides being costly, and another method of arriving at the amount of loss to be charged is adopted. A manufacturer knows by experience, or can ascertain from the maker, the probable duration of the machine. The number of years for which it can be used is divided into the cost price, and the amount thus obtained is charged each year in the profit and loss account as an expense of the business. There are more scientific methods of arriving at the amount which should be charged or written off, but they can be dealt with appropriately later.

Possibility of Obsolescence. Besides wear and tear to the machine there is a further matter to be considered when dealing with an asset of this nature. Human ingenuity is constantly devising new and improved methods of manufacture in practically all industries, and this factor should be taken into consideration when forming an opinion as to the period for which the machine will be valuable. For in the event of a new machine being placed on the market of such a nature as to render it impossible for the manufacturer to continue his present methods owing to the adoption by his rivals of the cheaper or quicker system, he would have to regard his machine as obsolete, and put himself on an equality with them by installing one of the latest pattern.

From these remarks it will be seen that there are elements which render it impossible to place absolute reliance upon the estimate formed, however carefully it may have been made. The utmost that can be done is to take into consideration every contingency that can be foreseen and form a conclusion upon those premises.

The remarks upon the question of wear and tear apply to the other fixed assets mentioned on the preceding page, save only the freehold land and the goodwill, for it is clear that neither horses nor carts improve with age, that motor vehicles seriously depreciate, and that if the business has had the benefit of their services it must not only be charged with the wages of the carmen and forage, petrol, tyres, and stabling, but also with the decrease in value which has taken place in consequence of the horses and vehicles being used for the purposes of the business. Fixtures stand in the same position as machinery, and the decrease in their value must form a charge in the same fashion.

Patent Rights. Patent rights stand upon rather a different footing. Patents are granted for a period of fourteen years, during which the patentee has the sole right of using the invention forming the subject of the patent. At the end of that time the general public will be at liberty to use the invention, and, as an asset, the invention will have disappeared, subject to any value there may be in the goodwill which may have been built up by the patentee as sole maker during the existence of the patent. With this reservation, therefore, the patentee has to contemplate the certain loss of a particular asset within a known period, and he should take steps to extinguish the book value by writing off a proportion each year as depreciation. The same course should be adopted with the book value of leasehold premises, the amount written off depending principally upon the number of years the lease has to run.

The only remaining item in our list is goodwill. Except in the case of a steadily losing business this cannot be said to depreciate regularly. It may fluctuate with the rise and fall of the profits of a business, but it should rarely be appreciated in the books, and is, on the contrary, frequently written down either directly or indirectly by means of a reserve, which need not be explained here, but is considered later.

Method of Recording Depreciation. The manner in which the operations described are performed is to debit profit and loss account, and credit the particular asset to be depreciated. The debit to profit and loss is not, however, entered direct on that account. A depreciation account is opened and debited with the several items to be charged in respect of the various assets, the journal entry being made as follows:

Depreciation	Dr.	368	
To machinery			200
,, Horses, carts, and motors			75
,, Fittings			25
,, Patent			68

being the amounts to be written off for depreciation during the year as agreed by partners.

The depreciation account will be closed by transferring the balance to the debit of the profit and loss account by a journal entry.

It only remains to be said that in the case of the fixed assets the depreciation written off is shown in the inner column of the balance sheet as a deduction from the book value before the amount was charged, the net amount being extended.

J. F. G. PRICE

Interest, Simple and Compound. Present Worth and True Discount. Bills of Exchange and Commercial Discount.

INTEREST AND DISCOUNT

INTEREST

120. If a person borrows money, he usually pays something for the loan. The sum of money he borrows is called the *Principal;* the money he pays for the use of the principal is called *Interest.* Interest is generally reckoned at so much for the use of each £100 for one year. This amount is called the *Rate per Cent. per Annum.*

Thus, if we say that £200 is borrowed for three years at 4 per cent. per annum, we mean that the borrower, at the end of each year, pays the lender £4 for each £100 borrowed—*i.e.*, £8 interest for each year.

In the above example, where the interest is supposed to be paid to the lender at the end of each year, it is clear that the interest is proportional to the number of years—that is, the interest for two years is twice the interest for one year, the interest for seven years is seven times that for one year, the interest for one month is $\frac{1}{12}$ that for one year, and so on. Interest thus reckoned is called *Simple Interest.*

If, however, the interest at the end of the first year is unpaid, it is added to the principal and thus forms a new principal for the second year. Consequently, the interest for this second year will be more than the interest for the first year. When the interest is added, year by year, to the principal, as it becomes due, the money is said to be lent at *Compound Interest.*

The sum obtained by adding the interest for any given time to the principal is called the *Amount* in that time.

121. Suppose we have to find the simple interest on £420 for three years at 5 per cent. per annum.

The number of hundreds borrowed $= \frac{420}{100}$

$\therefore$ Interest paid each year $= \frac{£5 \times 420}{100}$

$\therefore$ Interest paid for 3 years $= \frac{£5 \times 420 \times 3}{100}$

Hence we see that

$$\text{Interest} = \frac{\text{Principal} \times \text{rate} \times \text{time (in years)}}{100},$$

or, in other words, *to find the simple interest multiply the principal by the time expressed in years, and by the rate per cent., and divide the product by* 100.

Example 1. Find the Simple Interest on £162 10s. for four years at $3\frac{1}{2}$ per cent.

$$\text{Interest} = \frac{£162\frac{1}{2} \times 4 \times 3\frac{1}{2}}{100}$$

$$= \frac{\overset{13}{\cancel{325}} \times \cancel{4} \times 7}{\cancel{2} \times \cancel{2} \times \underset{4}{\cancel{100}}} = £\tfrac{91}{4} = \underline{£22\ 15s.\ \textit{Ans}}$$

The work may also be arranged as follows:

Example 2. Find the amount of £345 15s. 4d. in 15 months at $2\frac{1}{2}$ per cent. Simple Interest.

	£	s.	d.
4)	345	15	4
	86	8	10
2)	432	4	2
			2
	864	8	4
	216	2	1
	£10,80	10	
		20	
	16,10s.		
	12		
	1,25d.		
	4		
	1,00f.		

Explanation. 15 months $= 1\frac{1}{4}$ years. Write down the principal, and add one-quarter of it, giving £432 4s. 2d. Multiply this result by $2\frac{1}{2}$, giving £1,080 10s. 5d. Divide by 100 [Art. 25]. Thus, the interest is £10 16s. $1\frac{1}{4}$d., and Amount = Interest + Principal.

	£	s.	d.
∴ Interest =	10	16	$1\frac{1}{4}$
Principal =	345	15	4
∴ Amount =	£356	11	$5\frac{1}{4}$ *Ans.*

122. Since, Interest = Principal × Rate × Time ÷ 100, it follows that if we are given any three of the four quantities—interest, principal, rate, time—we can find the fourth quantity. In the last article we considered the case in which interest was the quantity to be found. We shall now work examples illustrating the other three cases—*viz.*, to find the rate, to find the time, and to find the principal.

Example 1. At what rate per cent. will the Interest on £175 for 4 years amount to £24 10s.?

Either, by proportion, find the interest on £100 for 1 year (which is the required rate), knowing that the interest on £175 for 4 years is £24 10s. Thus

$$\left.\begin{matrix} £175 : £100 \\ 4\text{ yr.} : 1\text{ yr.} \end{matrix}\right\} :: £24\ 10s. : \text{Required Rate.}$$

$$\therefore \text{Rate} = \frac{24\frac{1}{2} \times 100}{175 \times 4} = \frac{\overset{7}{\cancel{49}} \times \overset{4}{\cancel{100}}}{2 \times \underset{7}{\cancel{175}} \times \cancel{4}} = \underline{3\tfrac{1}{2}\%\ \textit{Ans.}}$$

Or, find the interest on £175 for 4 years at 1 per cent. and divide the result into the given interest. Thus—

Interest on £175 for 4 years at 1 per cent.

$$= \frac{175 \times 4}{100} = £7.$$

$$\therefore \text{Required rate} = \frac{£24\frac{1}{2}}{£7} = \underline{3\tfrac{1}{2}\%\ \textit{Ans.}}$$

Note. If we are given the *amount* instead of the *interest*, we must first find the interest by

subtracting the principal from the amount and then proceed as above.

Example 2. In how many years will £175 amount to £199 10s. at $3\frac{1}{2}$ per cent.?

Here, interest = £199 10s. − £175 = £24 10s.

We now find the interest on £175 for 1 year at $3\frac{1}{2}$ per cent. and divide the result into the given interest.

Interest on £175 for 1 year at $3\frac{1}{2}$ per cent.

$$= \frac{£175 \times 3\frac{1}{2}}{100} = \frac{7 \times 7}{2 \times 4} = £\tfrac{49}{8}.$$

∴ Required number of years

$$= £24\tfrac{1}{2} \div £\tfrac{49}{8},$$

$$= \frac{49}{2} \times \frac{8}{49} = \underline{4 \text{ years } \textit{Ans.}}$$

Example 3. Find the Principal which will amount to £199 10s. in 4 years at $3\frac{1}{2}$ per cent.

The interest on £1 for 4 years at $3\frac{1}{2}$ per cent.

$$= \frac{4 \times 3\frac{1}{2}}{100} = £\cdot 14$$

∴ £1 is the principal, which amounts to £1·14 in 4 years at $3\frac{1}{2}$ per cent.

$$\therefore \text{ Required Principal} = \frac{£199\frac{1}{2}}{1\cdot 14}$$

$$= \frac{\overset{25}{\cancel{100}} \times \overset{7}{\cancel{399}}}{\cancel{2} \times \underset{\cancel{2}}{\cancel{114}}} = \underline{£175 \textit{ Ans.}}$$

If we are given the interest, instead of the amount, we proceed in the same way—*i.e.*, we find that the interest on £1 for 4 years at $3\frac{1}{2}$ per cent. is £·14, and then we know that Required Principal = Given Interest ÷ ·14

123. If the time, for which the interest is required, is from one given date to another, such as "April 12th to July 14th," we do not count the first of these days. In the case just mentioned, interest would be reckoned for 30 − 12, *i.e.*, 18 days of April, 31 of May, 30 of June, and 14 of July, making a total of 93 days.

124. Compound Interest. From what has already been said about Compound Interest it is plain that we find the Amount in any given time by calculating the Simple Interest for each year in succession, the Principal, of course, becoming greater in each succeeding year. The Compound Interest for the whole period will be the difference between the Amount and the original Principal.

The work can be more compactly arranged by using £'s and decimals of a £, than by using £ s. d.

Example. Find the Compound Interest on £1375 for 2 years at 3 per cent.

£1375	= 1st year's Principal.
41·25	= „ Interest.
1416·25	= 2nd year's Principal.
42·4875	= „ Interest.
1458·7375	= Amount.
1375	
£83·7375	= Total Interest.
20	
14·7500s.	
·75	
12	
9·00d.	£83 14s. 9d. *Ans.*

Explanation. To find the interest for 1 year at 3 per cent. we multiply £1375 by 3 and divide by 100. Hence our second line is obtained by multiplying 1375 by 3 and moving the digits two places to the right. Then, adding 41·25 to 1375, we get £1416·25 for the second year's principal. We now repeat the process—*i.e.*, multiply 1416·25 by 3 and move the digits of the product two places to the right. This gives 42·4875 for the second year's interest. Add this to the second year's principal, and we obtain the Amount. Subtract the original principal, and we have £83·7375 for the Compound Interest. The £·7375 is reduced to shillings and pence, as in Art. **91**, Ex. **3**.

125. Before proceeding further, it will be convenient to consider how the labour of finding Compound Interest may be lessened.

Suppose we have some decimal, such as 5·27463, and that we are asked to write it "correct to three places." This means that we are to write down a number of only three decimal places which shall be as near as possible to the actual value 5·27463. The result is 5·275. For the given decimal is 5·2746... and 46 is nearer to 50 than to 40, so that 5·275 is nearer the true value than is 5·274.

Similarly, the value correct to two places is 5·27.

Again, our smallest coin is the farthing. Hence it is unnecessary, in practice, to express any sum of money more accurately than "to the nearest farthing"—*i.e.*, we take a value which differs from the true value by no more than half a farthing. Now, 1 farthing = £$\frac{1}{960}$ = £·001041... which is very nearly equal to £·001. Thus, if we have a sum of money expressed as a decimal of a £, correct to three places, it will be correct to the nearest farthing. Therefore, in working Compound Interest, if we reject figures beyond the fifth decimal place we shall still obtain the value correct to three places—*i.e.*, to the nearest farthing.

Example. Find the amount at Compound Interest of £38 2s. 6d. in 3 years at $2\frac{1}{2}$ per cent.

£38 2s. 6d.	
= £38·125	= 1st year's Principal.
2·5	
·76250	
·19060	
·95310	= 1st year's Interest.
38·125	
39·07810	= 2nd year's Principal.
2·5	
·78156	
·19535	
·97691	= 2nd year's Interest.
39·07810	
40·05501	= 3rd year's Principal.
2·5	
·80110	
·20025	

1·00135 = 3rd year's Interest
40·05501
£41·05636 = Amount.
20
1·12720s.
12
1·52640d.
4
2·10560 far.
£41 1s. $1\frac{1}{2}$d. *Ans.*

EXPLANATION. Multiply by 2 and move the digits two places to the right, as in Art. **124**. Next, in multiplying by ·5, the first figure of £38·125 which gives a digit in the *fifth* place is the 2. Hence we begin multiplying at the 2, exactly as if the multiplicand only consisted of 38·12. Similarly, in finding the second year's interest, the first digit of 39·07810 which, when multiplied by 2, gives a digit in the fifth place is the 8; and when multiplying by ·5 the first digit required is the 7. Proceeding in this way, we obtain £41·05636, of which not more than the 41·056 will be correct, but this, as we have seen, gives a result correct to a farthing. If we work out the above example in full, we find that the Amount is £41·056455078125. This, when reduced to £ s. d., gives £41 1s. $1\frac{1}{2}$d. + ·196875 farthings; *i.e.*, £41 1s. $1\frac{1}{2}$d., which agrees with the first result. Evidently then, it is a mere waste of labour to work the example in full.

126. In some cases we are told that the interest is payable half-yearly, or quarterly. We proceed in the same way as before, except that we find the interest for a *half* year (or quarter year), and add the principal, to obtain the principal for the second half year (or quarter year), and so on, until we reach the end of the required time.

127. As in Simple Interest, if we are given the Amount (or the Interest), the Rate per Cent., and the Time, we can find the Principal.

First, find the Amount (or the Interest) of £1 for the given time at the given rate. Then the principal is found by dividing the given amount (or interest) by the amount (or interest) of £1.

128. Present Worth and Discount. Suppose a man has borrowed £100 at 4 per cent., payable after one year. His debt at the end of the year will be £104. Suppose, also, that he finds himself in a position to discharge the debt at the end of six months, instead of letting it go on for the full year. Clearly, instead of paying £104, he should only pay such a sum as, put out to interest at 4 per cent., will amount to £104 in the remaining six months. By the method of Art. 122, Ex. 3, such a sum is found to be £101$\frac{49}{51}$, or £101 19s. 3d., nearly.

This £101 19s. 3d. is called the *Present Worth* of the £104 due in six months at 4 per cent. The difference between the present worth, £101 19s. 3d., and the amount which would be due in the six months, £104, is called the *True Discount.*

Thus, the problem of finding the Present Worth is exactly the same as that in Art. **122**, Ex. **3**, when the interest is simple; and is the same as Art. **127** if the interest is compound.

Example **1**. Find the Present Worth, and True Discount, on £40 8s. due in 73 days at 5 per cent.

Interest on £100 for 73 days at 5 per cent. $= \frac{1}{5} \times 5 = £1$.

$\therefore$ Present worth of £101 = £100.

$\therefore$ Reqd. Present Worth $= £\frac{100 \times 40\frac{2}{5}}{101} = £40$ ⎫ *Ans.*
$\therefore$ True Discount = £40 8s. − £40 = 8s. ⎭

Example **2**. Find the Present Worth of £1458 14s. 9d. due in 2 years at 3 per cent. Compound Interest.

£1.
·03
1·03 = Amount in 1 year.
·0309
1·0609 = Amount in 2 years.

$\therefore$ Present Worth of £1·0609 = £1.

$\therefore$ Present Worth of £1458 14s. 9d.

$= \frac{£1458·7375}{£1·0609}$

1·0609)14587375(£1375 *Ans.*
39783
79567
53045

EXPLANATION. Find the amount at 3 per cent. compound interest of £1 for 2 years, *viz.*, £1·0609. Reduce 14s. 9d. to the decimal of £1. Then, since £1 is the Present Worth of £1·0609, the required Present Worth is the quotient of 1458·7375 by 1·0609.

BILLS OF EXCHANGE

129. In commercial transactions, an agreement to pay a sum of money at some stated future date is made by a *Bill of Exchange*, or by a *Promissory Note*. [See CLERKSHIP, page 663.]

Suppose a merchant, James Brown, receives an order for goods to the value of £200, from another merchant, John Smith. Instead of paying cash, Smith authorises Brown to draw a Bill, to be paid by Smith after a certain period, usually three months. Brown accordingly writes out the Bill of Exchange, as follows:

Birmingham,
13th November, 1905.

£200.

Three months after date, pay myself, or order, the sum of two hundred pounds, value received.

James Brown.

To
Mr. John Smith, Merchant, Leeds.

The bill is forwarded to Mr. Smith, who "accepts" it—*i.e.*, acknowledges the debt, by writing "Accepted," followed by his signature, across the face of the bill, and returns it to Mr. Brown. The bill is nominally due in three months after November 13th, but the law allows three extra days, called *Days of Grace*; so that it legally falls due, or "matures," on February 16th.

Brown may keep the bill till February 16th and then "present" it for payment, to Smith, or Smith's banker, who will pay the £200.

Brown may, however, before February 16th, sell the bill to a third person, either a banker or a *Bill-broker*, for cash. The broker is then said to have *discounted* the bill. As the broker has still to wait a certain time before Smith pays the bill, he will not pay Brown £200 for it. Suppose Brown gets the bill discounted on December 5th "at 5 per cent." Then, the number of days before the bill falls due is $26 + 31 + 16 = 73$ days. The broker, therefore, calculates the interest on £200 for 73 days at 5 per cent., and deducts that amount (£2) from the *Face Value* (£200) of the bill. He thus pays Brown £198 for the bill.

The amount which the broker deducts from the face value is called *Commercial*, or *Banker's, Discount*. We see, then, that the problem of finding the Banker's Discount is the same as that of finding the Simple Interest on the face value, for a given time, at a given rate (Art. **121**).

130. The ordinary form of Promissory Note is as follows:

Leeds,
13th November, 1905.

Three months after date I promise to pay to Mr. James Brown, or order, the sum of £200, value received.

John Smith.

It should be noticed that in the case of a Bill of Exchange the document is written by the creditor, while a promissory note is written by the debtor.

131. Since,

Amount (*i.e.*, Face Value) = Present Worth + True Discount, it follows that

Interest on Face Value = Interest on Present Worth + Interest on True Discount; that is,

Banker's Discount = True Discount + Interest on True Discount.

The difference between the Banker's Discount and the True Discount is, therefore, the interest on the True Discount.

Example. The difference between the Banker's and the True Discount on a certain bill due in 2 years at 5 per cent. simple interest is £1 13s. Find the Amount of the bill.

We know that £1 13s. is the simple interest on the True Discount for 2 years at 5 per cent.

Therefore, by the method of Art. 122, Ex. 3, we can find the true discount. For £10 is the interest on £100 for 2 years at 5 per cent. Hence,

£10 : £1 13s. :: £100 : True Discount.

$\therefore$ True discount $= £\dfrac{100 \times 33}{200} =$ £16 10s.

The Banker's Discount is, therefore, £16 10s. + £1 13s. = £18 3s., and we have now only to find on what principal the interest for 2 years at 5 per cent. amounts to £18 3s.

$\therefore$ £10 : £18 3s. :: £100 : Required Bill.

$\therefore$ Amount of Bill $= £\dfrac{100 \times 363}{200} =$ £181 10s. *Ans.*

EXAMPLES 16

1. Find, to the nearest penny, the Simple Interest on £2523 11s. 6d. for 5 years at $3\frac{1}{2}$ per cent.

2. At what rate per cent. Simple Interest, will £875 amount to £980 in 3 years?

3. The simple interest on a certain sum for 8 years at $4\frac{1}{2}$ per cent. is £183 3s. Find the Sum.

4. In what time will money double itself at 4 per cent. Simple Interest?

5. Find, to the nearest penny, the Amount of £1420 in 3 years at 6 per cent. Compound Interest.

6. Find, to the nearest penny, the Compound Interest on £58 4s. 7d. for 2 years at 4 per cent., the interest being payable half-yearly.

7. Find the Present Worth of £231 1s. $10\frac{1}{2}$d. due in $2\frac{1}{2}$ years at $3\frac{1}{2}$ per cent. simple interest.

8. Find the True Discount on £1447 0s. $7\frac{1}{2}$d. due in 3 years at 5 per cent. Compound Interest.

9. A bill due in 3 years is discounted at 4 per cent. The difference between the True Discount and the Commercial Discount is 10 guineas. Find the Amount of the bill.

ANSWERS TO EXAMPLES 15

1. To lose 5 per cent, he must sell for 95 per cent. of cost. To gain 7 per cent., he must sell for 107 per cent. of cost. $\therefore$ 95 : 107 :: £247 : Required Price. Hence, he must sell for $247 \times 107 \div 95$ £278 4s. *Ans.*

2. He buys *equal* numbers at the two rates, and sells 5 for 3d. Take, then, the L.C.M. of 2, 3, and 5, *i.e.*, 30. Now 30 at 2 a 1d. cost 15d., and 30 at 3 for 2d. cost 20d. The total cost is 35d. He sells the whole 60 at 5 for 3d., *i.e.*, for 36d. He thus gains 1d. on an outlay of 35d. His gain % is $\frac{1}{35}$ of $100 = 2\frac{6}{7}$ *Ans.*

3. 9s. 7d. – 9s. 2d., *i.e.*, 5d., is 4 per cent. of the cost, or $\frac{1}{25}$ of the cost. $\therefore$ Cost $= 25 \times 5$d. = 125d. Hence, by selling at 9s. 7d., he loses 10d. His loss per cent. is $\frac{10}{125}$ of $100 = 8$ per cent. And, therefore, by selling at 9s. 2d. he loses $8 + 4 = 12$ per cent.

4. 750 eggs at 15 a shilling cost $750 \div 15 = 50$s. He loses 2 per cent. of this, *i.e.*, he loses 1s. But the number of eggs he lost was 113. Hence he sold $(750 - 113) \div 49$, or 13 eggs for 1s.

5. 24 lb. of tea at 1s. 10d. cost £2 4s.; 8 lb. at 2s. 10d. cost £1 2s. 8d. The total cost of 32 lb. of tea is, therefore, £3 6s. 8d. To gain 10 per cent. he must sell the 32 lb. for $\frac{110}{100}$ of £3 6s. 8d. Hence, the selling price per lb.

$$= \frac{11 \times £3\ 6s.\ 8d.}{10 \times 32} = 2s.\ 3\tfrac{1}{2}d.\ \textit{Ans.}$$

6. As in Art. **119**, Ex. **5**, if he buys 5 per cent. cheaper and sells to gain 4 per cent. he sells for $\frac{95}{100} \times \frac{104}{100}$ of actual cost $= \frac{247}{250}$ of actual cost. But he really sells to gain 10 per cent., *i.e.*, for $\frac{11}{10}$ of cost. Therefore, £168 is $(\frac{11}{10} - \frac{247}{250})$ of cost. Whence, cost = £1500, so that to gain 10 per cent. he must sell for £1650 *Ans.*

H. J. ALLPORT

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The Chance of the Man who can Manage Things

TAKING RESPONSIBILITIES

THE ancient virtue of courage is just as necessary to the modern man as it was to his primitive ancestor. In all our varied walks of life, the courageous man of action still wins to the front, in spite of the defects of his virtue. He may be less studious than his rivals, and possess less knowledge and less experience, but by sheer force of character he will usually succeed. His success is often a baffling problem to his competitors. They measure themselves against him in quickness and reach of mind, and they feel certain that he is less well equipped than they. And they are often able to assert with justice that he is inferior to them in the common, useful qualities of prudence and cautiousness. Yet the man with nothing exceptional save a striking force of character will in most cases be seen to rise at last far above the men who appear at first to have better opportunities than he had.

Every invention and change of method that disturbs the routine of life in our complex civilisation serves to bring out the high value of the courageous man who will shoulder responsibilities. And it is remarkable how rare are men of this sort. Persons with a good conceit of themselves are not uncommon, but when it comes to the test of facing unforeseen difficulties in a silent, steady, masterful way, ordinary self-conceit often fails a man, and leaves him more a nuisance than a help to those who confided in his powers.

Yet even the worst form of self-confidence is better than a complete lack of courage. At the present day there is a great multitude of men with talent, knowledge, and experience who seem never to be able to rise above the position of a good subordinate. With every widening of the field of enterprise these men increase in number. For each advance in our civilisation, that tends to open careers to all classes, shows that Nietzsche, the fierce modern German thinker, was right in holding that some men are born to serve, even as others are born to command. Yet the only difference between the born servant and the born commander is the quality of courage.

In power of intelligence, in studiousness, and in subtlety of mind the born commander may be at a disadvantage. In many cases he has little or no originality, and only just enough knowledge to rub along with. His best ideas, and a good deal of his working information, are obtained at second-hand from the men under him. So these men are generally inclined to regard themselves as the superiors in ability to the man who commands their services, and to attribute his success to luck or influence or favouritism.

Their own failure is put down to a lack of capital or of ambition. Certainly the want of capital is a great restriction for men of talent with small, comfortable positions in very large establishments. But if they have superior qualities of intelligence it is no bar against their rising to a position of importance in their firm, and becoming the chiefs of their departments. But the men of whom we are speaking seldom rise to a position of control, and never keep that position even if they attain it. They are excellent advisers at times, and work well under a man with more courage and active initiative; their overwhelming defect is that they are afraid to take any important responsibility. Some of them flinch at the risk; others have their best faculties suddenly numbed when the moment comes for them to act alone.

The trouble is that this fear of responsibilities seems to spread with the advance of culture and general education. It is the special disease of the well-educated mind. At present, for instance, France and Germany are countries with a more efficient system of secondary education than Great Britain possesses. In these two Continental nations, with their high level of culture, ordinary individuals seem to be more averse from taking responsibilities than are, as yet, the general body of our countrymen. In France, according to Emile Faguet, one of the keenest of modern French critics, the fear of respon-

sibility has grown into a national malady. The best-trained minds are afraid to go into business or commerce, and overcrowd in the attempt to get into the Civil Service, looking on its life of routine and official guidance as a refuge from the brave activities of an independent career. Nearly everybody plays, so to speak, for safety, instead of working adventurously for some high success. So the general creative strength of the race declines, in spite of the wonderful agility and brilliance of the French mind.

In Germany a similar condition of things is beginning to obtain. A German merchant, with offices in London and Berlin, says that he now finds that an English office-boy with an elementary education is formed of a more promising material than the German clerk from a good school. The boy knows scarcely anything, while the clerk speaks at least two modern languages, and is quick to learn the details of the business. But, according to the merchant, his clerk will not act on his own responsibility, while the office-boy, on the other hand, is eager to show some power of initiative before he even has the knowledge necessary for effective action. The German who remarked these things took the view, very flattering to our race, that the difference between his office-boy and his clerk was an affair of national qualities. "The drill-sergeant," he remarked, "teaches us the lesson of obedience so thoroughly in early manhood that we are afterwards afraid of doing anything without an order." It may be possible that the Continental system of military training induces a general habit of obedience at the expense of the individuality that makes a man great in himself.

But we are afraid that the British middle classes are becoming almost as averse from taking responsibilities as is the French or German bourgeoisie. Every progress in civilisation increases the sheltering influences of our lives. The protected days of our boyhood lengthen out; and at an age when our grandfathers were earning their own living, many of us are still at school.

So there arises a difficulty which we must be prepared to meet. In our pursuit of knowledge we must always remember that knowledge of every sort is a means and not an end. The most disinterested seeker after wisdom is compelled to admit that learning is only a means to action. Beyond and above the realm of the understanding is the sovran dominion of the will. The man of science and the philosopher degenerate into mere smatterers if they let their minds play over a store of knowledge without taking the responsibility of coming to a decision, and then working with the fine new zest that is born of the exercise of the active powers of a man.

Men of a very studious habit of life are usually inclined to irresponsibility. This defect of theirs must be guarded against by every student who begins by seeking after knowledge as an instrument of existence. He must never allow himself to yield to the subtle temptation of feeding his intelligence at the expense of his will-power, as the bookworm does. Both in his intellectual recreations and his training for a career he should always beware of regarding the temple of knowledge as a quiet, dispassionate retreat where a man is safe from the rough, tumultuous realities of life. Otherwise his intellectual pursuits will weaken his powers as a man of action, and make him one of these pale, picturesque ineffectual figures who evoke the Philistine's scorn of those scholarly attainments which, rightly used, are of effect in every important walk of life.

There is nothing like the rough and tumble of existence to teach a man the virtues of responsibility. And an alert intelligence may learn more by observation than by actual experience. If we study the men around us, and distinguish between their mental gifts and their strength of spirit, we shall soon learn to appreciate the qualities that make for success. For instance, we have all met, at some time or other, the man who seems bound to succeed but never does. He can talk brilliantly and seems to be overflowing with sound ideas. Loud is he in relating the tale of the great things he has done for others, of the openings he found and other persons followed, of the fine chances that came to him but were snatched up by some self-seeking friend. Men of this sort have generally some weakness of character. It is more likely to be the subtle weakness of fleeing from responsibilities than some notorious failing of the vulgar sort. Yet to a man with the right spirit there are few things easier to acquire than a delight in exercising his powers of decision and action.

Human nature is a material that can be moulded in surprising ways, and even the grand qualities of leadership can be taught. Since the days of Arnold of Rugby, our public schools have directed all available forces to this desirable end. Games have become as important as book lessons for training boys to take responsibilities, practically without knowing that they are being schooled for some of the highest duties in life. It is mainly because of this system of character training that our public schools manage to produce a class of lads so capable of holding their own against lads of the Continent, who possess a larger and better-digested store of information. The average British public school boy is remarkable neither for the keenness of his intelligence nor for the range of his mind. He wins through heavy difficulties by his solidity of character. In an emergency he is ready to act without any help or direction. The time he loses in blundering is less than the time lost in hesitations and indecisions by a more knowledgeable man who is afraid of responsibility.

As fine a training in responsibility as a public school offers can be obtained by any young man who is willing to work for it. There are clubs and societies that constantly need officers—secretaries, treasurers, and managers of some kind or another. There is usually no salary attached to the positions, and so there is often very little competition for posts that ask for a considerable amount of administrative toil that has to be done without reward. But the reward for such service comes in something better than money, and in avoiding a responsible position on the executive staff men are often letting their best powers wither for want of employment.

The men and women who volunteer to act as the honorary officers of the innumerable little associations that play so large a part in our social life are well rewarded for their pains. They get a training in leadership, administrative work, and in responsible activities which is invaluable. It matters little how small the scope of their labours is; their character receives a new bent, if only they show themselves adequate to the task they have undertaken. They have escaped from the land of soft jobs where everything runs on the grooves of routine, and they have begun to breathe the more bracing air of the rougher uplands of life.

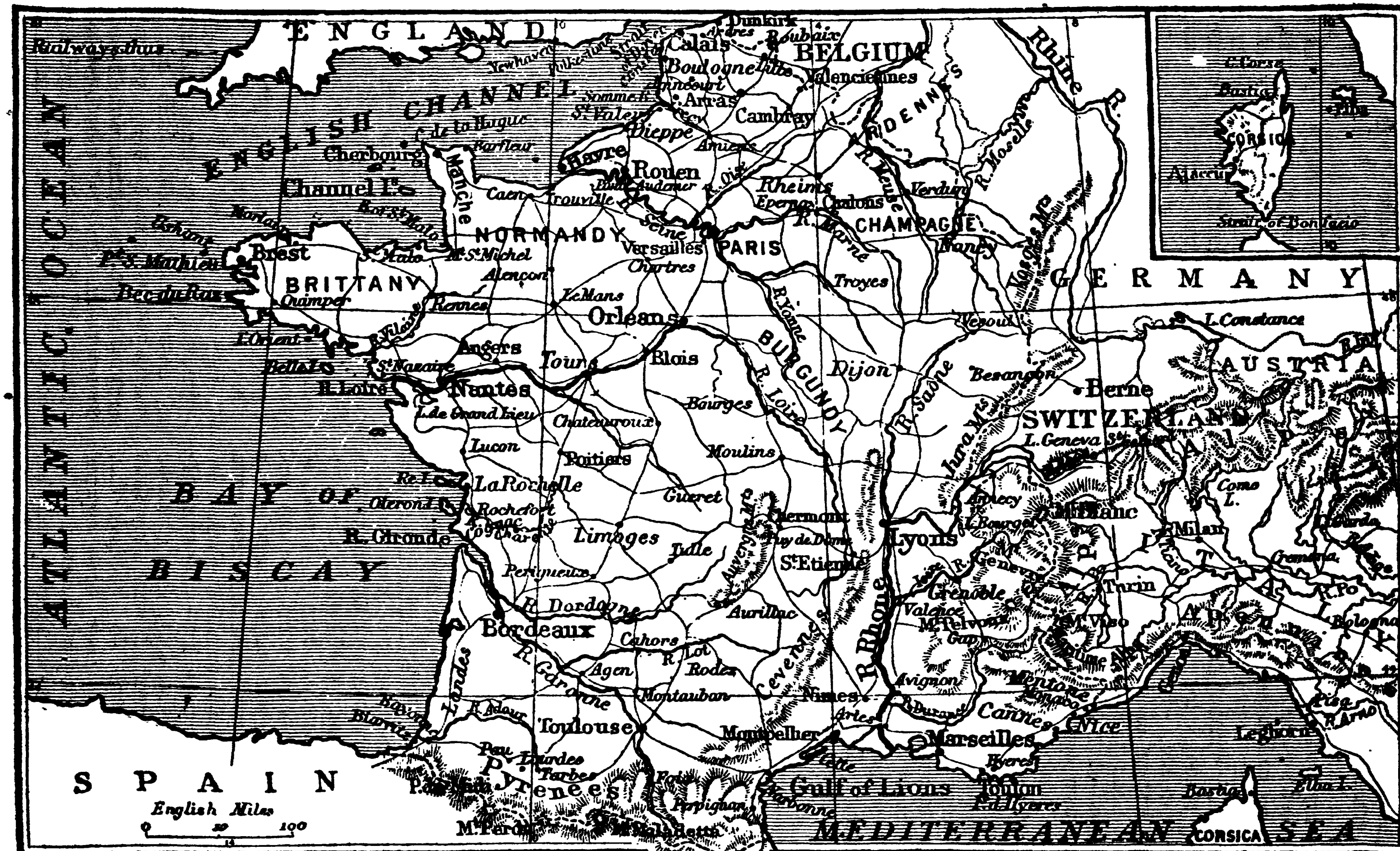
It is not good to be always on the look-out for what are called "soft jobs." The best of these, as a rule, lead nowhere, and the men who enjoy them grow "soft" also, and become so smugly prudent that they are incapable of a more virile, inspiriting, and adventurous way of life. Worries, anxieties, and problems are attached to almost every position of responsibility; and though they appear to take their toll of a man, they really exercise the forces of his character and expand his personality. A shorthand clerk usually has an easier life than the merchant he works for. If he wishes to improve his position, he must find a way of sharing some of the responsibilities—the wearing, creative work of the business, and so free his employer from some of the cares about the markets, the sales, the characters of customers. He must help actively in extending the resources of the firm and in overcoming its difficulties.

In short, he must make himself a creative part of the business organisation. If no opening of the kind is likely to occur within a reasonable time, it would be better for him to look about for a change of employment, using his present means of livelihood as a stepping-stone to some post with more troubles, higher pay, and larger scope. It is here that mere self-conceit will fail a man who mistakes it for self-confidence. For self-conceit will often blind a man to the fact that he is not properly qualified for the higher work he wishes to undertake. A man with a true sense of responsibility will always feel answerable to himself, and will therefore take pains to equip himself with a means of carrying out the task he proposes to do. For it is of the essence of responsibility that a man should be true to himself; this is the only way in which he can fulfil his engagements with others.

A responsible man never takes a risk and gambles with his career for the sake of a change of occupation. Indeed, he is more often a plodder than a sprinter. His distinguishing feature is his courageous spirit. A difficulty inspires him instead of daunting him, and calls out the reserve powers of his nature. Such is the man for whom the modern world is full of opportunities. For big jobs increase in number with every advance of civilisation and invention. The man who can manage things is wanted everywhere.

EDWARD WRIGHT

THE PLEASANT AND BEAUTIFUL LAND THAT LIES TO THE SOUTH OF ENGLAND



A MAP OF FRANCE, SHOWING ITS RELATIVE POSITION TO THE NEIGHBOURING COUNTRIES

Position, Climate, and Products. Mountains and Rivers. Paris. The Rhone, Saône, Seine, Loire, and Garonne. The Landes and Corsica.

THE PLEASANT LAND OF FRANCE

FRANCE (204,000 square miles) fronts three seas—(1) the English Channel on the north, (2) the Atlantic on the west, (3) the Mediterranean on the south. On all shores it has excellent harbours and busy ports, with easy access to all parts of the world. Its lowlands are broad and compact, forming a great semicircle around the Atlantic and the Channel. On the Mediterranean coast the highlands approach nearer to the sea, but, except in the extreme east, there is a coastal plain of no great breadth, widening in the centre to the plain of Languedoc. Every part of the most populous district, therefore, has easy access to the sea, and, as the canal system of France is excellent and extensive, all manner of merchandise can be easily and cheaply transported to the most distant parts of the country.

Climate and Products. France is as favoured in climate as in situation. The surrounding seas make the winters mild and the summers cool, though in the south the latter are hotter than an Englishman finds pleasant. The Atlantic winds bring rain, and as the coast is low the rainfall is more uniformly distributed than in Britain, where the mountainous west is too wet. Except in the highlands, the soil is generally fertile, and admirably cultivated, for France is, in the main, an agricultural country.

Normandy, opposite the Isle of Wight, is a chalk region like Southern England, which it resembles in climate and products. Its apple orchards and cider are famous. Farther east much sugar beet is grown. Brittany, opposite Cornwall and Devon, resembles them in scenery, climate, and products. The centre, with its warm, sunny summers, ripens magnificent harvests of wheat, and brings the vine to perfection. In the south, in addition to the vine, the olive is grown for oil, and the mulberry to feed silkworms, and in sheltered spots along the Mediterranean oranges and lemons ripen in the open air.

The Peasant and the Land. The French peasant commonly owns the land he works, and he gets a good living from it. Economy of soil is his watchword. The hillsides are terraced, especially in the vine districts, and not an inch of soil is wasted between the rows of vines. A fruit-tree is put in if there is room, and, if not, a fruit-bush. If that is too large, the peasant makes room for a clump of potatoes, asparagus, or artichokes, or at least for a patch of salad. In the plain the farms make a dazzling show from April to November, with "sky-blue flax, dark-green hemp, crimson clover, bright yellow colza, golden wheat, stately Indian corn, and creamy buckwheat"—all cultivated, perhaps, on a farm of two or three acres. Fruit-trees cover the houses, line the roads, and form the hedges. Add to these poultry, and it is not wonderful that the French peasant saves money, for he has much to sell and comparatively little to buy.

Coal and Iron Manufactures. France would have been a different and, perhaps, a less generally prosperous country had coal been abundant instead of scarce. Iron ores are important in Lorraine. The largest coalfield is in the north-east, on the Belgian frontier, where numerous towns manufacture textiles, of which Lille and Roubaix are the chief, obtaining cotton and wool through Dunkirk and the Channel ports. A number of smaller coalfields are found round the Central Plateau, and support iron and textile industries. The most important is that of St. Etienne, which manufactures iron and steel, and sends coal to the famous silk factories of Lyons.

These are not the only manufacturing centres, but in the others coal has to be brought from a distance. French manufactures, therefore, are mainly those in which a high degree of skill or taste compensates for greater cost of production, and they cannot compete in cheap, common articles. Unemployment, therefore, does not become so acute as with us, nor is there the same rush from the country to the towns.

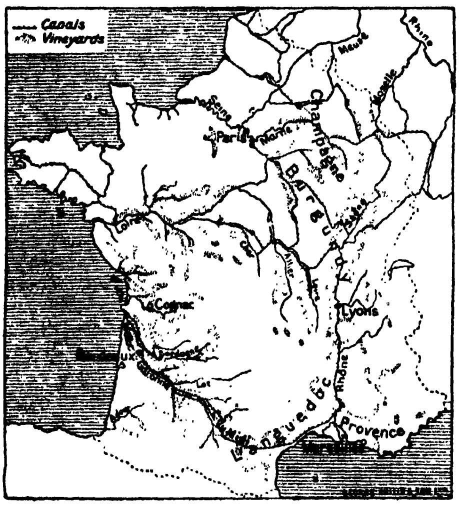
The Highlands of France. The highlands are in the east and centre. In the north-east, partly in Belgium and Germany, are the Ardennes, with the Meuse flowing through their western part, with the Moselle flowing round the south-eastern base of the Rhine, and farther south the Vosges—both forested. Round the former, near the northern coalfield, are Valenciennes, Cambray, and other towns, manufacturing cotton and wool, the latter produced in part on the hill pastures of the region. To the Vosges, where cotton is also manufactured, the raw materials are brought by the Seine and the canals connected with it, and coal from the coalfields of Lorraine. Water-power is also used more and more after being transformed into electricity. These northern highlands are connected westwards with the Plateau of Langres, the lower slopes of which produce the famous wines of Burgundy.

The Seine basin to the north is a series of clay plains and limestone and chalk heights, on the slopes of which grow the grapes from which champagne is made. To the south rises the Central Plateau, with bare tablelands of granite, where cattle are reared, and of limestone with sheep farms; here are also volcanic mountains, the soil from which, when carried to the Loire and Allier plains intersecting the plateau, makes them

very fertile. The south-eastern rim of the plateau, known as the Covennes, forms the western wall of the Rhone valley, east of which, cut by the valleys of rivers descending to the Rhone, rise the Jura and French Alps, the latter with forests and pastures below and snow peaks above. In the small Jura towns such industries as clockmaking are carried on, often by the aid of water-power.

The Rhone-Saône Valley and the Riviera. This valley separates the Central Plateau of France from the Alps, and opens a route from the north to the Mediterranean. Had it not existed, France would have been, in no real sense, a Mediterranean power.

The Saône rises in the Plateau of Langres, and flows south-west and south through the wine districts round Dijon, receiving tributaries from the Jura on the left bank. It joins the Swiss Rhone, from the Swiss Alps, at Lyons—a great industrial town, manufacturing local



THE CANALS AND VINEYARDS OF FRANCE

and imported silk with St. Etienne coal. The united river flows south in a valley which widens as the mountains on either side recede, through a land of olive, wine, and silk, to the plain of Languedoc, where it forms a great delta with marshes and lagoons. Marseilles, the chief port of the Mediterranean, is some distance east of the delta, and beyond is Toulon, the French naval station. Here begins the picturesque coast of the Riviera, with white towns—Hyères, Cannes, Nice, and many others —half hidden in palms and orange groves, while behind rise the snowy summits of the Alps.

West of the Rhone delta is Nîmes, with a large Roman amphitheatre, the old university town of Montpellier, and the wine port of Cette. Other southern towns are Narbonne, commanding an important route to the west by Toulouse between the Central Plateau and the Pyrenees, and Perpignan.

The Pyrenees. The Pyrenees rise like a wall between the Mediterranean and the Bay of Biscay, forming the frontier between France and Spain. The highest peaks are about 11,000 ft. high, and there are few easy passes. The lower slopes are forested with oak and beech, the higher summits rocky or snow-clad. Of many health resorts, Pau and Biarritz may be mentioned.

The Atlantic Lowland. From the base of the Pyrenees, the Central Plateau, the Vosges, and the Ardennes, stretches a great semicircular lowland, extending to the western and northern seas, and broken by heights along the English Channel. It is continued east beyond the French frontier by the lowlands of Holland, Belgium, and Germany. This is a fertile agricultural region, with many prosperous towns, often with fine cathedrals and public buildings, showing that the region has long been peaceful and prosperous.

From the highlands, three great rivers, the Seine, the Loire, and the Garonne-Dordogne, flow north or west, each with a special character of its own.

The Seine Basin—a Familiar Landscape. Northern France, with its orchards and wheat fields, reminds an Englishman of his own country, for the rolling chalk landscape of Southern England is also found on the French side of the narrow Channel. His eye misses the hedgerows between field and field, and notes that the poplar gradually replaces the elm. Unfamiliar touches are the blue blouses of the peasants, and women doing hard field work instead of men.

If the Englishman sails from Dover he lands at Calais, on the margin of the industrial district round Lille and Roubaix, both woollen towns. From Folkestone he arrives at Boulogne, a busy port, and makes his way, near the battlefields of Creçy and Agincourt, to the Somme, on which is Amiens, with a magnificent cathedral. From Southampton he reaches Havre, exactly opposite, at the mouth of the Seine, and, if he will, may sail up that river to Paris, the capital of France. The first great town he reaches, with its iron cathedral spire, many churches, and forest of factory chimneys, is Rouen, the Manchester of France, whose docks admit ocean-going steamers, laden chiefly with cotton. Elbœuf, not far off, manufactures woollens. Paris, 70 miles direct from Rouen, but much farther by water, is one of the gayest, brightest cities in Europe. It is built on islands in the Seine, and on both banks. The finest of its ancient buildings is the cathedral of Notre Dame. Its modern quarters have broad streets with avenues of trees, great squares with fountains and triumphal arches and columns, dazzling shops, and parks great and small. Many industries are carried on, and the city is the great place of exchange, both for merchandise and ideas. Not far below Paris the Seine receives the Oise, from the Ardennes, and above it its tributaries spread out like a fan, offering a choice of routes into the heart of the country.

Tributaries of the Seine. The Marne, entering the Seine just above Paris, has flowed down from the Plateau of Langres,

through a wine country, a few miles south of Rheims, in whose ancient cathedral French kings were formerly crowned. Rheims has now important woollen manufactures. A splendidly engineered canal, nearly 200 miles long, goes by Bar-le-Duc, and near the university town of Nancy, to the Meuse and Moselle, and thence across a depression in the Vosges to the Rhine near Strassburg. Or we may follow the Seine through the forest of Fontainebleau, and past Troyes, to its source in the Plateau of Langres. Finally, the Yonne takes us towards the Loire, which is separated from it by broken heights. The Burgundy Canal, 1,200 feet above the sea at its highest point, goes from the Yonne by Dijon to the Saône, thus connecting the English Channel with the Mediterranean.

Normandy and Brittany. East and west of the lower Seine is Normandy, its swelling hills covered with cornfields, and its valleys rich with orchards and meadows. Innumerable herds of cattle supply milk for the famous Normandy cheeses. Many towns, cathedrals and abbeys tell a tale of long prosperity. Cherbourg, opposite the Isle of Wight, on the Cotentin peninsula, is a naval station. Dieppe, east, and St. Malo, west of the Seine, are important packet and fishing ports. A few miles north of the latter are the Channel Islands. Brittany, opposite Cornwall and Devon, is a highland region, growing early vegetables in the north. Fishing is important all along the Channel coast, and both Normans and Bretons are born sailors. On the Atlantic coast are the naval ports of Brest and Lorient.

The Loire Basin—a Garden Land. The Loire, 550 miles long, the longest river in France, rises 4,500 feet above the sea, in the heart of the Cevennes. It is a rapid river, liable to destructive floods in its lower course, where its banks have to be protected by dykes and embankments. The main stream flows generally north as far as Orléans. On a tributary in its upper course is St. Etienne, with collieries, ironworks of all descriptions, and ribbon and other manufactures. Below Nevers it unites with the Allier, greater than itself in volume, which flows from the volcanic district of Auvergne, not far from Clermont, the largest town of the Central Plateau, in a fertile wheat and vine growing vale with a rich volcanic soil. All round this volcanic region, whose scores of extinct craters, seen from the summit of the Puy de Dôme, produce an indescribable impression on the mind, are mineral springs of high repute, as at Vichy, on the Allier. At Orléans, the centre of one of the most fertile districts of Europe, the Loire turns west, to flow by Blois, Tours, Angers, and many a famous château, through the rich districts of Berri, Touraine and Anjou, which form the garden of France. On the left bank it receives tributaries from the Central Plateau and on the right bank tributaries from the Norman heights. Nantes, at the head of the estuary, is the Liverpool of Western France, and the rival of St. Nazaire at its mouth.

The Garonne-Dordogne Basin. The Garonne is formed by the union of streams from the Pyrenees, which unite above Toulouse, a town important from Roman times because it commands the route to the Mediterranean between the Cevennes and Pyrenees. This depression is followed by the Canal du Midi, from Toulouse to Cette, uniting the Garonne with the Mediterranean. On the right bank the Garonne receives many tributaries from the Central Plateau, and these flow through some of the strangest scenery in Europe.

A Strange Country. The surface of the limestone Causses, as these districts are called, is a bleak, lime-stone plateau, burnt up in summer, and buried in snow in winter. The only sign of life is an occasional shepherd with his flock. The rivers cut deep narrow gorges many hundreds of feet below the surface, enclosed between rock walls carved into strange shapes by wind and weather, and flaming with all the colours of sunset. Precipitous paths lead down to the bottom of the gorges, which are often inaccessible except by boat, but in places widen out sufficiently to hold many a village, with orchards and gardens, hidden, as it were, in the bowels of the earth. The few towns are often finely situated on precipitous ridges.

The Dordogne. The largest tributary of the Garonne is the Dordogne, which rises in the old volcano of Mont Dore, in Auvergne. It enters the Gironde estuary a few miles below Bordeaux, the chief port of south-west France and the outlet for the clarets of the surrounding wine districts. Pauillac, at the mouth, is the outport of Bordeaux.

A Reclaimed Desert. The Landes. Immediately south of the Gironde is the wine district of Medoc, and beyond are the desolate Landes, a region of sand dunes, in places 250 feet high, and extending inland for 120 miles. Their advance eastwards has been checked during the last century by planting millions of pines, which yield valuable turpentine. The vine has also been successfully introduced. The inhabitants live in small scattered villages and cross the dunes on tall stilts.

Corsica. The mountainous island of Corsica (3,400 square miles), in the Mediterranean, is over 100 miles from France, of which it forms a department. Its mountains rise to nearly 9,000 feet. The lower hill slopes facing the sea are planted with olives, vines, oranges and lemons. Above there are dense forests of evergreen trees peculiar to the Mediterranean. Minerals are abundant, but little worked. The capital is Ajaccio.

A. J. AND F. D. HERBERTSON

A valuable Series of Technical Dictionaries, explaining Special Terms and Phrases, appears at the end of the Self-Educator.

THE RHYTHMIC MOVEMENT OF THE HUMAN FIGURE AS EXPRESSED BY BOTTICELLI

THE ALLEGORY OF SPRING. A CHARACTERISTIC PRODUCT OF THE NEW LEARNING

The Art of Filippo Lippi and Botticelli. The Umbrian School. Raphael, Andrea del Sarto, and Titian.

THE GREAT ITALIAN MASTERS

RENAISSANCE painting, like architecture and sculpture, was born in Florence, and its cradle is the Brancacci Chapel in S. Maria Novella, with the frescoes of Masaccio, the source from which many succeeding generations of artists drew their inspiration. It was the tendency of the Renaissance to give its due to the human body, to deliver it from the tyranny of the spirit, and Masaccio (A.D. 1401 to 1428) was the first of the painters to represent the nude living in all its beauty and strength, as in the "Expulsion" and the "Baptism." He also departed from the generally prevailing practice of arranging the figures of his compositions in one row, in the manner of the ancient relief, or of placing them one above the other in diminishing size. His figures occupy their right places in the receding planes of the landscape and live in the surrounding atmosphere. They are full of dignity and expression, and the folds of their draperies have the amplitude of the best classic models. His work marks an immense step forward in the direction first indicated by Giotto.

His artistic heritage was divided among many of his followers, chief among whom is Fra Filippo Lippi, the worldly friar, whose love of life and beauty found expression in many exquisite easel pictures and in the fine frescoes at Prato and Spoleto Cathedrals. The emotions expressed by him are not purely spiritual, like those of Fra Angelico, but intensely human. A healthy, robust type of peasantry served for his models; and his sense of beauty and loveliness and pleasure in the joys of the world is reflected by the gay splendour of his palette. Domenico Veneziano, who is credited with the introduction of oil-painting in Italy, was, above all, a master of technique, a naturalistic painter whose chief concern was the pictorial rendering of movement and expression. Paolo Uccello was a scientist, chiefly absorbed in the investigation of the laws of perspective, and an excellent painter of horses, dogs, birds, and other animals. His colour was frequently quite arbitrary, and used almost in the manner of the mediæval illuminators. The National Gallery possesses an interesting battle picture from his brush, illustrating how the field of painting had widened since its liberation from the exclusive rule of the Church.

Under the cloak of Scriptural illustration, Benozzo Gozzoli (A.D. 1420 to 1498), a follower of Fra Angelico, dealt in his extensive series of frescoes in the Pisan Campo Santo with general scenes of contemporary life, in which the customs, costumes, and types of his day are recorded with vivacious charm and great truth to Nature. His frescoes at the Riccardo Palace represent a scene of gorgeous pageantry of fifteenth-century Florence. Among those who were strongly influenced by Masaccio, the sculptors Verrocchio and Pollajuolo took a high place in the art of their time, though only few of their pictures have come down to us.

The Renaissance leaning toward classic learning found its supreme expression in Fra Filippo's pupil, Sandro Botticelli, one of the most personal and fascinating of the world's great masters. His strength lay in the marvellously expressive use of decorative line, the like of which can only be found in the art of Japan. He used colour not so much to deceive the eye into belief of the plastic reality of things as to strengthen the effect of the line. The rhythmic movement of the human figure in dance, the fluttering of drapery or of flowing locks in the wind, cannot be expressed more happily than in his "Allegory of Spring" and "Venus Rising from the Sea." For his compositions he was more concerned with producing a beautiful decorative pattern than with making the figures live in their surroundings, which are frequently quite conventional. Botticelli was profoundly steeped in the "New Learning" of the period, and his pictures often show a curious blending of the pagan and the Christian spirit. His "Madonna" and his "Venus" present very much the same type of face; they are both

melancholy, timid, pure, scarcely beautiful, but nevertheless intensely fascinating.

Filippino Lippi. Botticelli became in his turn the master of his master's son, Filippino Lippi (A.D. 1457 to 1504), who combined many of Botticelli's qualities with a sense of dainty beauty in expression and rich colour. In his earliest important work, the completion of the frescoes begun by Masaccio in S. Maria Novella, he tried with remarkable success to adapt himself to the manner of his great precursor; but in his later frescoes in the Strozzi Chapel he introduced such a florid mass of "Renaissance" detail, classic architectural motives with a tendency to over-decoration, Roman armour and trophies and instruments, that one is apt to overlook the really remarkable expressiveness in the varied gestures and movement of the figures. His most charming qualities appear quite unadulterated in such easel pictures as his "St. Bernhard," in the Badia in Florence, and the "Madonna with SS. Jerome and Dominic," at the National Gallery.

Pietro della Francesca (A.D. 1415 to 1495), of Borgo S. Sepolcro, in Tuscany, stands between the Florentine and the Umbrian schools. The transparent golden tone in which his landscape and figures are bathed is the earliest approach to the modern conception of painting open-air sunlight. He, too, was a master of perspective and foreshortening, and was endowed with a rare sense of pure beauty. One of his finest works, the "Baptism of Christ," is to be seen at the National Gallery. His pupil, Luca Signorelli, of Cortona, the author of a great series of frescoes at Orvieto Cathedral, may perhaps best be described as a painter of human limbs and of muscular activity. He delighted in illustrating scenes in which he could introduce seething, passionate crowds of unclothed humanity in every possible stage of violent movement; but he was not a painter of the "nude" in the modern sense—that is, an artist who will paint the figure for its beauty of form and surface texture. For that his drawing was too hard, his colour too dry; and the charm of the female form escaped his perception.

The Umbrian School. Umbrian painting was an offshoot of the Sienese school, modified by Florentine teaching. It never attained artistic independence, and was always more or less tied to the illustrative tendency. The Umbrians were more concerned with tenderness of sentiment and intensity of religious expression than with form and line and movement for their own sake. A long succession of minor artists, who need not here be enumerated, culminates in Pietro Perugino, the most typical, as he was the most accomplished, master of the school. His Scriptural pictures—and he painted few, if any, others—are peaceful, serene, detached from this world. He painted the life of the soul and not of the body; and the lovely Umbrian landscapes in which his figures are set, landscapes that open up the whole depth of space, range after range of billowing hills under a limpid blue sky, only enhance the effect of pure spirituality. As a master of space composition he was only surpassed by his great pupil Raphael.

To the same school belongs Pinturicchio, one of the most productive fresco painters of the fifteenth century. The decoration of the Borgia apartments at the Vatican in Rome and of the library of Siena Cathedral are his chief works—masterly space compositions, which, however, in their excessive love of splendour, of sumptuous gold, ultramarine and red, overstep the natural limitations of decorative wall-paintings.

Influence of the Paduan School. Meanwhile, the Renaissance movement had made equal progress in Northern Italy. In Padua, Squarcione, a painter who had travelled in Greece and brought back with him a fine collection of antique sculptures, was the founder of a school based on the study of these antiques. His great pupil Mantegna (A.D. 1431 to 1506) was entirely imbued with the classic spirit, and treated his paintings in a noble, sculpturesque style which has much in common with relief work. His "Triumph of Cæsar," now at Hampton Court Palace, shows the extent of his classical and antiquarian knowledge and his masterly draughtsmanship, though his frescoes in the Gonzaga Palace at Mantua, which have for their subject scenes of contemporary life, show even better the power of his brush. The Paduan school exercised considerable influence over Milanese and Venetian art in the fifteenth century, particularly over Bramantino in Milan and the Vivarini in Venice, though Venetian painting was soon directed into other channels.

The Splendour of Venice. The powerful mercantile Republic of Venice was never the soil for humanism that Florence had been. Accustomed to gorgeous pageants, pomp and ceremony, and luxurious life, and living in an atmosphere that cannot but develop a keen sense of beautiful mellow colour, these wealthy traders required an art that should be neither academic nor didactic, an art that should not reflect classic knowledge or stimulate thought, but an art that should reflect the splendour of their daily surroundings and appeal direct to the senses through the musical quality of colour. In Florentine painting colour had always been subordinate to line; the Venetians were the first school of real colourists—painters who thought in colour, not in line; who studied the colour appearance of Nature, and rendered the true appearance of things in pigment—true painters, in fact, in the modern sense of the word. The introduction of oil-painting by Antonello da Messina was of inestimable advantage to the achievement of this new ideal.

The Bellini Brothers. Giovanni and Gentile Bellini show already the germ of the Venetian tendencies which were to culminate in Titian and Tintoretto. Gentile revelled in historical processional pictures of Venetian life, a type of work in which Vittore Carpaccio achieved the greatest fame. Giovanni Bellini's paintings have a noble, classic dignity of style, an almost monumental character. He strove

for the typical rather than the individual. His colour is rich and harmonious, though not as sensuous as that of the later masters. Two other masters of the earlier Venetian school must here be mentioned—Carlo Crivelli, a pupil of the elder Vivarini, and strongly influenced by Mantegna; and Cima da Conegliano, whose altar-pieces are full of character and glowing colour. Crivelli, whose love of carefully executed detail rivals the early Flemish masters, is magnificently represented at the National Gallery.

Towards the end of the fifteenth century there was scarcely a city in Italy that was not a centre of some important school, and could not boast of some masters of more than local reputation. When the sixteenth century dawned, painting, though still frequently employed for the decoration of architecture, had to a great extent become an end in itself, independent of the other arts.

Leonardo and Raphael. Leaving Venice and returning to Florence and Central Italy, we come to the man who inaugurated the greatest period in Italian art—the period when supreme technical mastery went hand in hand with ideal beauty and classic perfection.* This man was Leonardo da Vinci, that universal genius who could master and achieve greatness in every phase of intellectual and artistic activity.

Raphael was an eclectic who, gifted by nature with a rare capacity for assimilating all that was most admirable in the art of those that had gone before him, consciously combined these qualities in works that have for centuries been held up as the acme of perfection, and have, through academic teaching which encourages the cold, soulless imitation of all that is purely formal, exercised a deterrent influence on the evolution of art. Leonardo, too, had assimilated the accumulated experience of two centuries of painting, but with him this process was unconscious, and though the perfection of his work sounds a unique personal note, there was nothing his brush could not express—emotion or serenity, character or pure beauty, strength or tenderness. He was a master of line and of colour, of movement and expression. Volumes have been written about the deep significance of every figure in his "Last Supper" fresco, in Milan, now a complete wreck, which scarcely reflects a dim shadow of its former glory. And the mysterious, enigmatic smile of the "Monna Lisa" has become the stock phrase of a generation of art writers.

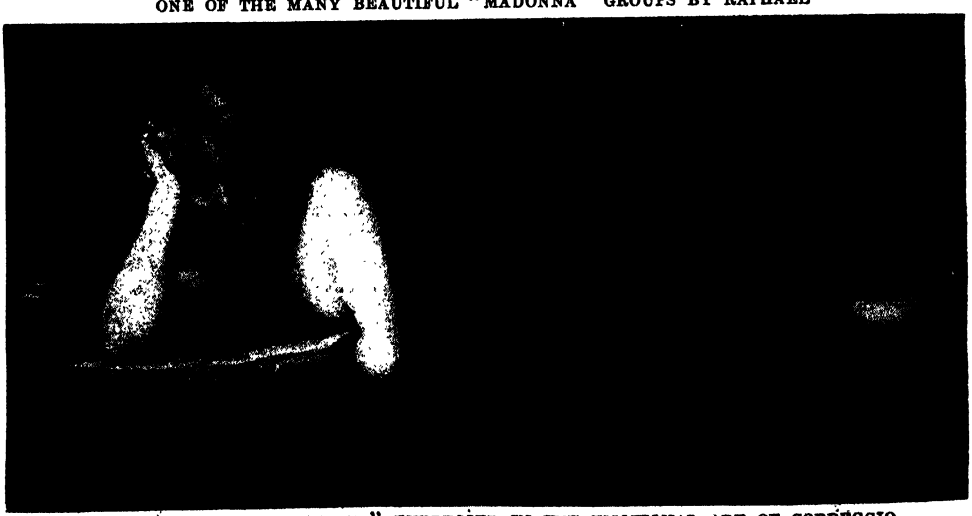
Called to the Court of the Sforza in Milan, Leonardo became the head of an important school, from which issued such masters as Luini, Beltraffio, Gaudenzio Ferrari, and the Sienese painter Sodoma. Leonardo himself produced but few finished works, and forms in this respect a marked contrast to his great rival Michelangelo, whose work is truly titanic in character and in extent. His ceiling of the Sistine Chapel alone would be no inconsiderable result of a life's work. We have already dealt with the master's sculpture. In painting he shows the same powerful grasp of the human form, the same passionately heightened vitality, the same grandeur of design. But he was not a colourist in the sense of the Venetians or of Leonardo. His genius was more sculptural than pictorial. His strong personality attracted many followers, of whom Sebastiano del Piombo achieved great fame, and even Raphael at one period fell under his spell.

"THE LAST SUPPER," BY LEONARDO DA VINCI

"The Perfect Painter." Of the other Florentines of the period, Fra Bartolommeo and Andrea del Sarto enjoy the widest fame. The former, a follower of Savonarola, eschewed all worldliness in his art, and painted in his early period many serious and solemn altar-pieces of great beauty and harmoniously blended, mellow colour, though later in life he attempted more ambitious works of pompous character, but without much significance. Andrea del Sarto, who earned the epithet of "the perfect painter," approached the Venetians in his conception of colour. Perfect in drawing, with a rare sense of beauty and grace, he lacked power of expression and depth of feeling. In Northern Italy, Correggio,* whose chief works are to be seen in Parma, is the most typical master of the late Renaissance. An artist of great nervous sensibility, he had little concern with nobility of

THE ART OF RAPHAEL AND CORREGGIO

ONE OF THE MANY BEAUTIFUL "MADONNA" GROUPS BY RAPHAEL



THE READING MAGDALENE," EXPRESSED IN THE EMOTIONAL ART OF CORREGGIO

MASTERPIECES OF FORM AND EXPRESSION

THE HOLY FAMILY AS CONCEIVED BY MICHELANGELO

THE THREE SISTERS—A WONDERFUL PORTRAIT GROUP BY PALMA VECCHIO

form and carefully measured rhythm of line. His art is intensely emotional; the expression of his "Madonna," as of his "Magdalen" and his "Io," is almost ecstatic in its intensity of delight or grief. His real medium is light and shade rather than colour and line, and he almost rivals Rembrandt in his rendering of chiaroscuro.

Raphael marks the turning-point of Italian art—Venice always excepted—which after his death degenerates into eclectic mannerism on the one hand and crude naturalism on the other. Of Raphael's pupils, Giulio Romano and Perino del Vaga continued for a while his tradition, but toward the end of the century Bologna took the lead. The Caracci and Guido Reni and Sassoferrato and other eclectics are, however, scarcely worthy of a place in a short survey of the world's art, except to typify the shallow depth to which painting had sunk after its glorious efflorescence at the beginning of the century. The naturalists flourished especially in Naples, where Ribera painted numerous scenes of torture and other horrors of a similar character with bold use of contrasts of light and shade.

Giorgione. In Venice the sixteenth century is inaugurated by three glorious masters—Giorgione, Palma, and Titian. Of the first of them only few pictures can be identified, but they suffice to secure him a position among the elect. He knew how to express the emotion of the figures in the surrounding landscape; he was the first, in fact, that did not paint the background merely to fill in a pleasing manner the space between and behind the figures, but made the figures live in their surroundings. He was an idealist whose art was the fruit of his imagination.

Palma. Palma, who owed much to Giorgione's example, was intoxicated with the sensuous beauty of Venice and of her daughters, and revelled in painting the luxurious charm of their rounded forms and golden hair.

Titian. Titian stands for the highest achievement of Venetian art. He was, perhaps, the greatest colourist the world has ever seen, and could do justice to every task by which a painter may be confronted. That he could express in terms of colour the most exalted emotions of the human soul is proved by such works as his "Assumption," at the Venice Academy. In space composition he rivalled the greatest Tuscans. The sumptuous glow of his colour is only rivalled by the rhythm of his linear composition, and in portraiture he ranks with Velasquez and Rembrandt.

Tintoretto and Paolo Veronese. While in the later part of the sixteenth century the rest of Italy was given over to uninspired eclecticism, Tintoretto and Paolo Veronese worthily upheld the great tradition of Venetian painting. The former, who had chosen the motto "The design of Michelangelo, the colour of Titian," was endowed with a fecund imagination, was a complete master of the human form, and of all effects of light, and a gigantic worker, who devoted himself with preference to decorative tasks on a monumental scale. His principal works were executed for the Doge's Palace and the Scuola di San Rocco, in Venice. Paolo Veronese, one of the greatest masters of composition and a sumptuous colourist, was, above all, the painter of Venetian festive life. His subjects, true enough, are chosen from Scripture, but the scenes are invariably clad in the gorgeous costume of sixteenth-century Venice, which they bring vividly before our eyes. He loved the beautiful surface appearance of things, and did not trouble to any notable extent about their inner meaning.


"ST HELENA," BY VERONESE

Canaletto. Tintoretto and Veronese are followed by many florid imitators, but the end of the seventeenth century produced a new "genre," of which the elder Canaletto is the chief representative. He was a purely objective painter of the architectural features of this floating city of palaces, which he recorded with great love of detail, without losing sight of the effect of massed light and shade. Francesco Guardi chose similar motifs for his pictures, but treated them in a less topographical spirit. His brush is more liquid and broad, his tone silvery and creamy, his atmosphere truer than that of Canaletto's.

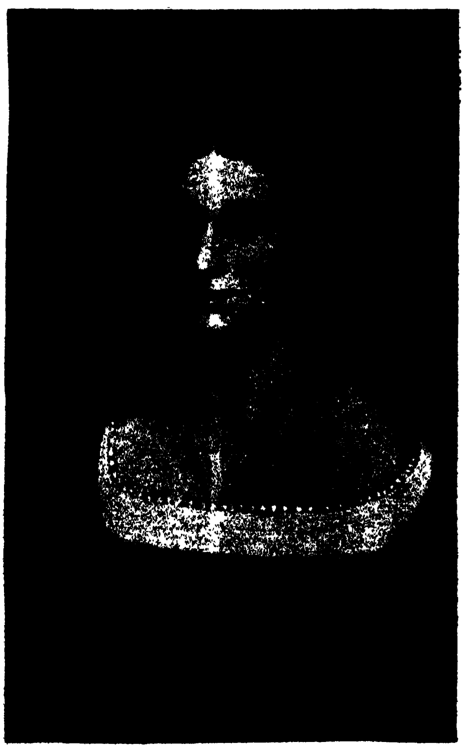
Tiepolo. The last of the masters of Venice was Tiepolo (1696-1770), who catered for the craving of his time for florid splendour—a great colourist, who modelled himself on his greater precursors of the sixteenth century, but totally lacking in ideas and expressiveness. He devoted himself chiefly to decorative paintings for ceilings and walls, and died in Spain, whither he had been summoned as painter to the Court of Madrid.

P. G. KONODY

FOUR PORTRAITS BY FOUR MASTERS

RAPHAEL'S "LADY WITH THE VEIL"

LEONARDO'S "LA BELLE FÉRONNIÈRE"

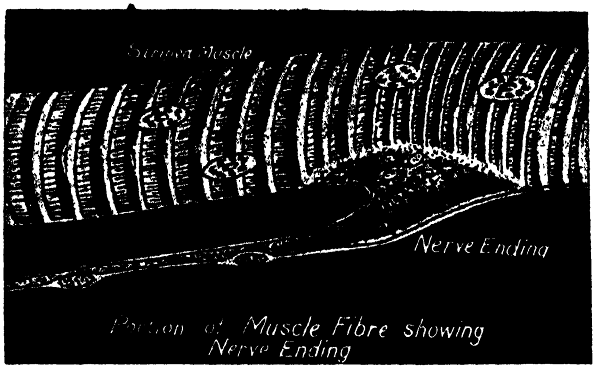


GIORGIONE'S "PORTRAIT OF A LADY"

TITIAN'S "LA BELLA"

THE MUSCLES OF A HUMAN BEING

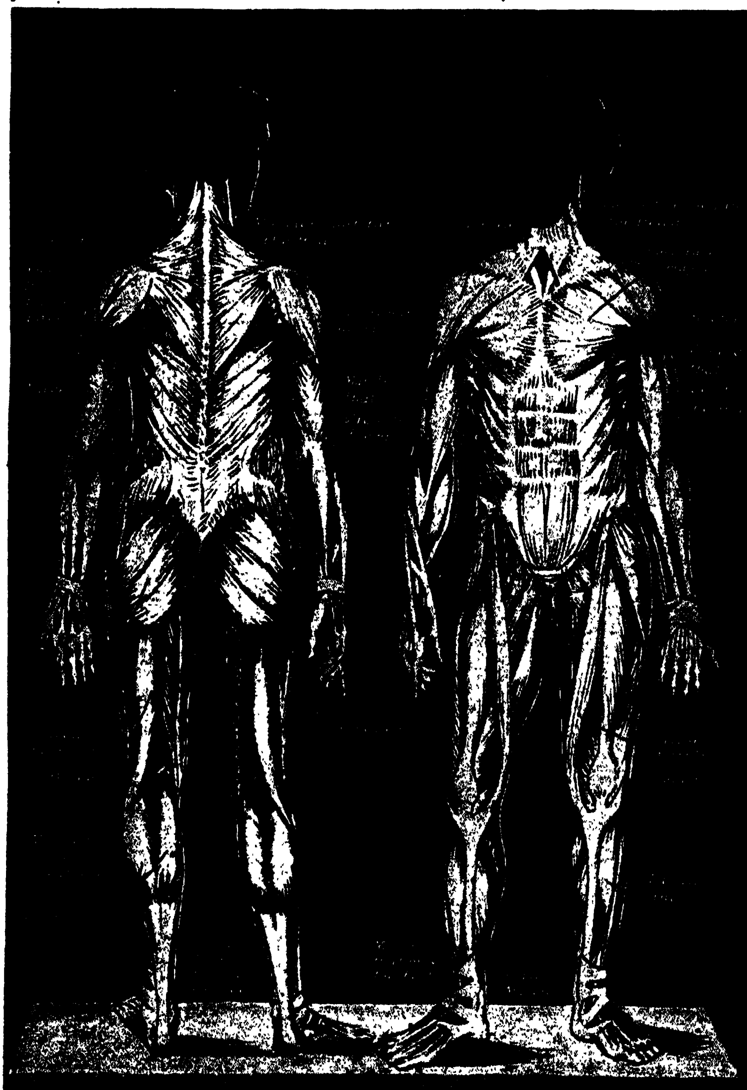
65. BICEPS OF ARM, SHOWING TENDONS



66. A PORTION OF STRIPED MUSCLE-FIBRE, THE PART TO WHICH THE NERVE IS JOINED BEING CONTRACTED

67. THE SOLE OF THE FOOT

68. WRIST AND HAND



69. THE MUSCULAR SYSTEM FROM TWO POINTS OF VIEW

70. THE RIGHT LEG

The Structure and Uses of Voluntary and Involuntary Muscles. How the Limbs are Moved.

THE MUSCULAR SYSTEM

We have now to consider the muscle, that contractive tissue which is the agent of all movement. We will look at their varieties, structure, and chemical composition, and the functions they perform. Muscles derive their name from *musculus* (Latin), a little mouse, because, being pointed at both ends and broad in the middle, they resemble one. All flesh is muscle, and all muscle is called flesh. The muscles are not *in* the flesh; *they are the flesh.*

Use of Muscles. There are about five hundred of them in the body—250 pairs and five single muscles. They cover all the bones, and are covered themselves by the fat and skin, as can plainly be felt if you grasp the arm. The flesh, therefore, does not cover the bones in a solid layer, but is composed of many separate muscles [69]. Each muscle is enclosed in a smooth, glistening sheath that separates it from the next, as you can sometimes clearly see in a leg of mutton. But although muscles cover, strengthen, and support the body, their principal use is to enable us to move. No movement can take place without a joint that can move and a muscle to move it. Muscles are of all sizes. There are very strong ones in the arms, and still stronger ones in the legs. The longest muscle in the body is nearly 2 ft. long, and reaches from the hip to the inside of the leg below the knee; is called the sartorius, or *tailor's, muscle,* because it draws the leg up when sitting cross-legged like a tailor. The smallest muscle is only ¼ in. long, and is in the ear. There are about 150 muscles in the back alone to keep the spine erect, and these are of great importance. The muscles that form the front of the abdomen, where there are no ribs, are just as important, because they have to protect all the internal organs. The calf of the leg is composed of muscles, and is connected with the strongest tendon in the body, called the Achilles tendon, placed just at the back of the ankle, where it is fixed on to the heel. A muscle, like all other tissues, increases in size by use, while, if it is not used, it wastes away.

Muscles constitute 45 per cent. of the weight of the body, and, besides forming a large part of the limbs, they are used internally to surround canals, organs, and vessels, either to regulate their size or their movements, to close their orifices, or for other purposes.

Voluntary and Involuntary Muscles. Muscles, broadly speaking, are of two varieties—the striped, or voluntary, and the unstriped, or involuntary. The former, under the control of the will as a whole, though not individually, are attached to all parts of the skeleton, move all the joints and bones, and are the organs of locomotion. They are connected with the animal life and the spending of force, and are set in action by voluntary nerve impulses. They act quickly, decidedly, and simultaneously in all their parts. They are capable of great exertion, but soon get tired. They are called striped because under the microscope narrow bands are seen running across them.

The unstriped, or smooth, muscles differ from these in almost every respect. They are concerned with the vegetative side of life, or the building up of force, and form a large part of all the internal organs and tubes; they are not under the conscious will, and derive their impulses from involuntary, or "sympathetic," nerves. They act in a slow, gradual manner, and never as a whole, but the motion spreads like a wave from fibre to fibre in a way called *vermicular.*

There is a third variety of muscle, found only in the heart, combining the characteristics of the other two. It is like the first in being striped, and in acting decisively and simultaneously, but resembles the second in being absolutely involuntary. The heart beats entirely without our will or knowledge, for by no effort can a man stop the beating of his own heart. This muscle is the busiest one in the whole body. It contracts the heart 70 times every minute, day and night, for perhaps 70, 80, or 100 years.

Structure of the Muscle. Turning now to the construction of a muscle, we see first of all by the naked eye that each muscle consists of separate bundles, all united together by the covering skin. The bundles are made up of smaller bundles, and these of smaller, and these again of separate fibres, which are the muscle-cells; they are like very short hairs, though when joined together they make up a large muscle.

Muscular fibres are well supplied with blood by means of small blood-vessels, which give flesh or muscle its red appearance. The fibres themselves are composed of a row of what look like oblong black and white beads called *sarcous elements,* and a nerve runs to each muscular fibre from the brain, and is attached to it by a flat plate, as shown in 66.

How a Muscle Contracts. The nerve-current is supposed to act like an electric shock on the sarcous elements that make up the muscle fibres, and thus make each element as broad as it was long, so that the whole fibre gets at once shorter and wider. It is in this way that muscle moves, as we see more fully in the next section.

All these separate fibres are bound together by connective tissues, and all the connective tissue-sheaths join together at each end of the muscle to form the firm white fibrous band, or tendon, that unites it to the bones [65]. Sometimes, as in the great muscles in the neck of a horse, by which it can wrinkle up its skin and shake the flies off, the muscle is very thin, and spread out like a piece of cloth.

Muscle is soft and thick in the middle, and a band or tendon fastens it at each end to the bones it has to move.

The contraction may be imitated by tying a strong piece of elastic to the handles of a pair of scissors. The handles will represent two bones, where the scissors cross is the joint, and the elastic is the muscle that can draw the handles together if they are stretched apart.

Before a muscle acts, and while it is at rest, it is just like a *stretched band of tape;* but the moment the nerve current reaches it from the brain, the muscle suddenly becomes like a stretched band of indiarubber. All muscular movements are thus produced by the current the brain has the power to send along the nerve, for it can make the muscles like stretched bands of rubber. If you let your arm hang down, and catch hold of the middle of it with the other hand, and then bend the forearm up, you will feel the muscles getting thicker and harder under your hands; *so that a muscle causes motion by becoming shorter and thicker.*

Chemical Composition of Muscle. The general composition of muscle is as follows.

Water	75·0
Nitrogeneous matter	20·0
Muscle sugars, or starch	1·0
Salts and ferments	4·0
	100·0

Muscle is usually at rest, but as each fibre has a nerve running to it, the whole mass can be instantly contracted. The moment it is at work, or contracted, it becomes acid. It uses more oxygen and gives out more carbon dioxide to the blood, uses up the muscle sugar, producing nine units of heat for every unit of work, and getting broader and shorter. A muscle can contract three-fifths of its entire length, and only takes one-twentieth of a second to do so, but it soon gets tired, contracts less vigorously, and at last cease to move. Six hours or so after death it begins to coagulate and gets rigid—the state of *rigor mortis,* which lasts nine days.

Exercise Strengthens the Muscle. A muscle differs from all machines in becoming stronger the more work it does. We have so little occasion to move our ears that the little muscles have almost lost their power of contraction for want of use. Any part of the body not used wastes away, and at last becomes useless—that is, atrophied.

If the finger is placed in front of the ear when chewing, one can feel the muscle of the lower jaw contract; the muscles that pull it down can also be felt under the chin. At the back of the neck one may feel the two strong columns of muscle that keep the head erect upon the shoulders.

How the Limbs are Moved. The shoulders themselves are beautifully rounded by large, fleshy muscles that cover the bony surfaces, and end in strong tendons fixed in the upper part of the arms. It is these muscles that raise the arm and extend it level with the shoulder. Then we have strong chest-muscles fixed to the arm to draw it forward, and strong muscles behind fixed to the shoulder-blade and arm to draw it backward.

All along the arm are two sets of muscles. Those in front, including the biceps, are called *flexors,* because they bend the joint; those at the back are called *extensors,* because they extend the joint, so that one set pulls against the other. For instance, if you want to bend the arm with the biceps, the triceps muscle behind prevents it doubling up too easily.

To the outer side of the elbow are fixed all the muscles that form the back of the forearm and extend the back of the hand and wrist. The fleshy part of the muscle is in the upper part of the forearm, while the wrist consists of all the tendons coming down from the muscles above to be fixed in the bones of the fingers they have to move [68]. If you work the fingers about, you can see the tendons moving under the skin at the back of the hand. The one that goes to the thumb can be seen very plainly if you extend the thumb far back. To the inner side of the elbow are fixed the muscles that form the front of the forearm, and flex the front of the wrist and hand. These also end in long tendons that run in grooves. The middle tendon can be very clearly seen if you touch the little finger with the thumb, and bend the wrist forward.

The buttocks and thighs are all formed of enormous muscles, which move the leg in any direction [70]. The long tailor's muscle, 2 ft. long, which is like a ribbon, and reaches from the hip-bone to below the knee, enables us to sit cross-legged like the Japanese. The muscles that extend or straighten the leg are all in front; those that flex or bend it are all along the back, and form the calf below. The sole of the foot [67] is formed of *four separate layers of muscles,* one below another.

Unstriped Muscle. So far, we have only spoken in detail of those muscles with which we are most familiar, all of which are striped, and under the control of the will. But we have alluded to another sort of muscle that moves our internal organs and carries on all the processes of life inside us. Such muscles have *no stripes,* they are not large, and are composed of altogether different cell-fibres. They form part of the walls of the stomach and intestines, and of the blood-vessels, bladder, kidneys, and other organs. They are not in any degree under the control of the will, but are governed by another nervous system altogether, the seat of which is not the brain, but behind the stomach. It is called the sympathetic system. From here fine red nerves stretch to all these *unstriped* and involuntary muscles, which are composed of small, spindle-shaped cells $\frac{1}{250}$ of an inch long, cemented together in masses. They are not striped or made in small beads like the striped muscle, but are composed of contractile substance. Their movements appear to be spontaneous. They do not get fatigued, and they work day and night unknown to us.

A. T. SCHOFIELD

The Possibilities of Electricity in Agriculture. The Influence of the High-Tension Electrical Current on Crops of Various Kinds.

ELECTRICITY ON THE FARM

THE last few years have seen great changes in agriculture. The chemistry of the soil, the study of manures, the changes that take place in the growth of crops, have all been made the subject of strict inquiry. The modern farmer is to some extent a chemist and botanist, and his knowledge of live-stock has been extended in a very similar manner.

How Electricity Influences Growth. Electricity has long been known to exert a beneficial influence on the growth of vegetation. In the Arctic regions, where electrical disturbances are very frequent, it has been found that the vegetation is taller and in some cases more luxuriant than usual, and it was probably this fact that led to the earliest experiments in electro-agriculture. Professor Lemstrom, a Norwegian scientist, conducted a great number of interesting experiments as a result of these observations, and his early work showed in a marked degree how much plant life could be influenced by applying to it electric currents similar to those which ordinary atmospheric disturbances would supply.

His first trials were carried out in flower-pots in which different kinds of seeds were placed. The seeds were supplied with electricity from wires attached to a static electrical machine and stretched over the pots. The pots were placed on a window-sill, and the results were observed from day to day. These were so encouraging that further experiments were carried out under more favourable conditions, and for some years Lemstrom carried out systematic work with electricity which has furnished us with valuable data to go upon.

Striking Results of Lemstrom's Experiments. In the first place it was found that, in general, positive electricity is more beneficial than negative, though negative is better than nothing at all. It was found, too, that when the plants were positively electrified, they grew more quickly, and that the fruit was heavier. In the case of root plants, the grown plant was heavier, so that potatoes, or beetroots, or carrots were finer and larger. There were many discrepancies in the experiments. For instance, cabbages treated with electricity were worse than those grown in the ordinary way; but in this instance it was discovered later that they required a great deal more water, and that if this extra water was supplied, then the results were quite favourable.

Professor Lemstrom devised a large frictional electrical machine which could be driven by a hot-air engine or other means, and after extensive experiments he was able to determine what proportion the cost and upkeep of an electrifying plant bore to the results yielded. In a few words, it may be said that as a general rule the plant pays for itself in about three years, and that after that period something like 30 or 40 per cent. extra yield of the crops is produced, so that considerable profit should ensue.

Possible Reasons for Failure. We now come, however, to some discrepancies in the matter. Many experiments on a really commercial scale have been carried out since Lemstrom first completed his work, and many of these have been extremely disappointing. Others have given results so little better that the use of electricity has been shown apparently not to be worth while. In the minds of many agriculturalists, therefore, it is not by any means established that electrification of crops is worth doing, but those who have most closely watched this branch of science have good reason to feel confident of its utility.

One possible reason for failure, for example, was shown recently by the writer to be the application of *too much* electricity. Experiments made by him showed that every plant is in itself a sort of battery, and that the upper part of a plant is negatively electrified as compared with the roots. The difference of electric potential between the top of a plant and the root was measured, and found to be infinitely small. It was argued, therefore, that electric currents applied to plants should be of a similar character to those actually met with in Nature, instead of, as is often the case, currents much larger and entirely disproportionate being applied, with bad results.

Others have found that only bad results are obtained when the currents are applied in sunny weather, and it is generally accepted that successful application is confined to certain hours of the day, though no exact hours have been determined.

How the Current is Applied. The most modern electrical plant for agriculture is that devised by Sir Oliver Lodge and Mr. J. E. Newman, who have done a great deal of serious work in this country. In order to be sure that the current applied to the crops is only positive, Lodge invented a special valve through which the current is passed, and which only admits of the passage of current in one direction, so that any negative electricity is, so to speak, trapped, and cannot get through.

The current is usually supplied from an induction coil, similar to that used for X-ray work, which transforms up current of a few volts to current of many thousand volts. A six or eight inch coil—that is, a coil which will give a spark of six or eight inches in length—

is very suitable, the negative terminal of the secondary winding of this coil being connected to a plate in the earth, and the positive to a network of wires spread over the ground to be treated. Posts ten or fifteen feet high are placed in the ground at intervals of a few yards, and from the tops of these are suspended, from porcelain insulators, wires which all lead to one common terminal—the positive end of the coil. The wires are charged up to an enormous voltage by the coil, and this high-tension current gradually leaks away, or descends to the earth, leaking through the plants themselves, which act as miniature "lightning conductors" or collectors of the electricity.

The coil is worked from the electric mains, or in smaller sets of apparatus from a battery of accumulators, and is switched on for perhaps two hours twice a day, in the morning and again in the afternoon.

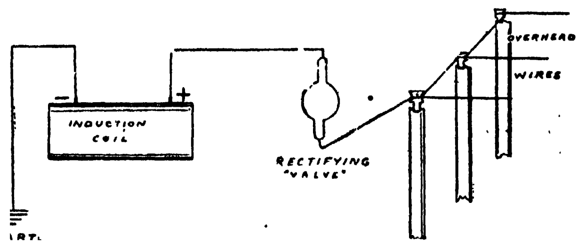


DIAGRAM EXPLAINING THE HIGH-TENSION CURRENT USED IN CROP STIMULATION

A Curious Discovery. The Lodge-Newman plant has been in operation on an extensive scale for some time now, and very satisfactory results have been obtained. Professor Priestley has established the interesting fact that high-tension current discharged from the overhead wires is blown about or carried by the wind for some distance, so that during windy weather the land to windward of the overhead wires would receive more benefit than that immediately underneath it. Such curious discoveries as this show that extreme caution must be used in arriving at any definite conclusions without making thorough tests, as in many instances bad results can be accounted for when inquiries are made into all the circumstances.

The investigation has been carried on recently by having a number of experiments made at different centres, so that the errors tend to neutralise one another. Mr. J. E. Newman made a recent statement to the effect that experiments had been carried out in this country for over eight years, and that on the whole the results had been uniformly good. But in addition to their use in this country, Lodge-Newman plants have been already employed in the United States and in Egypt.

Cost of the Installation. For treating an area of land of between twenty-five and thirty acres, the electrifying plant and the overhead wire installation cost about two hundred pounds; a larger plant capable of electrifying double this area would cost only about three hundred pounds.

With the older frictional electricity apparatus used by Professor Lemstrom the first costs are somewhat less, and it is claimed by him that the cost of a complete installation for twenty-five acres, would cost £109, and that in the cultivation of wheat an increased net annual profit of £44 could be anticipated.

What Recent Experiments Show. The following table shows the increased yield attributable to the application of electricity to the plants mentioned:

Wheat	about 21 per cent.
Oats	„ 19 „
Raspberries	„ 43 „
Peas	„ 75 „
Beans	„ 36 „

Experiments carried out recently in Germany showed that the ripening of strawberries could be hastened by several days by means of electrification, thus enabling the growers to command the highest prices at the beginning of the season. In these cases the current was applied in the morning between 7.30 and 9.30, and for two hours before dusk in the afternoon or evening. Applications of the current during rain were more or less useless, but during foggy weather they were most favourable.

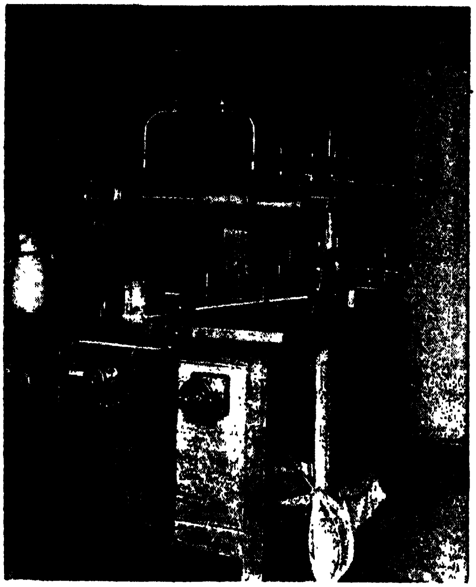
Another noticeable feature of the electrification, recently noted by the writer, and originally claimed by Professor Lemstrom, is that the amount of sugar in root crops is noticeably augmented, and considerable interest has been evinced by growers of sugar beet in this discovery. But where extra profit is looked for by users of electricity, there is little doubt that at present the experimenting with small gardens for intensive work is most desirable. Land intensively cultivated yields high profits for the acreage, and as a small electric plant for a market garden would cost comparatively little, any increase it produced in the yield would give proportionately greater benefit.

Radium as a Plant Stimulant. Electricity is not the only agent which can be employed to stimulate plant growth.

Interesting experiments have also been carried out lately with ultra-violet light, which has the effect of hastening germination, and greatly increasing the luxuriance of both foliage and flowers in greenhouse plants.

It has also been found that radium is a most powerful stimulant, and is only required in such minute quantities that its use is quite a possibility from the practical or commercial point of view. It has not yet been definitely ascertained whether, in view of the increased rate of growth, an abnormal amount of manure is required by the ground, or whether these phenomenal growths impoverish the soil at an unusual rate. But the results so far obtained as to the extra weight of root crops when radio-active soil is employed are both definite and promising. In the manufacture of radium there

ELECTRICITY AS AN AID TO PLANT GROWERS



THE LODGE-NEWMAN ELECTRICAL APPARATUS WHICH GENERATES THE HIGH-TENSION CURRENT

THE POST AND INSULATORS WHICH CARRY THE WIRE AFTER IT LEAVES THE GENERATING HOUSE

THE GREENHOUSES AT BITTON, NEAR BRISTOL, WHERE PLANTS ARE ELECTRICALLY STIMULATED

THE WIRE BROUGHT INTO THE GREENHOUSE THROUGH A PORCELAIN INSULATING BLOCK

PLANTS STIMULATED BY DISSIPATION OF ELECTRICITY FROM WIRES CARRIED ALONG THE ROOF

always remains in the final residues a microscopic amount of radio-active matter. It may be only a milligramme per ton, which means that about seventy tons of residue would contain one grain of radium. But it is quite impossible to extract this last trace, which is quite sufficient to produce good results, both on germination and in the rate of growth of the plants.

In a recent paper read at the Royal Society of Arts, the writer described some experiments where radishes grown in radio-active soil were over five times as heavy as those grown under similar conditions in ordinary soil. This enormous increase does not occur in every case, nor is the stimulation the same with every kind of plant. The action is selective. Radishes always appear to give very marked results, but cress seems to be little affected by the radio-activity, becoming only about seven per cent. heavier.

Back Garden Radio-cultivation. Tests of the radio-active powers can be easily made by anyone in his own garden if he obtain some of the radio-active residues which are used for preparing medical bandages or poultices. Some of these radium "earths" are alleged to contain radio-active matter, but unfortunately actually contain so very little that they have no effect. Some reliable firm should be approached which will supply "earth," that is, residue, containing at least one milligramme per ton, and this may be mixed with from five to ten times its own weight of ordinary soil. A simple comparison can be made by filling one flower-pot or flat box with this soil, and another with ordinary soil, and planting some radish and barley or oat seeds in each, and watching the results. If the soil is at all radio-active in the one pot, it will be found that the wheat grows to a much greater height than it does in ordinary soil in a given time; while the radishes will weigh much more.

EFFECT OF ELECTRICITY ON CARROTS

In these comparative results of four methods of growing carrots, the signs + and – show the direction of the current in i., iii., and ii. respectively, and in iv. no current was employed. The picture is reproduced from Professor Lemstrom's "Electricity in Agriculture" (issued by "The Electrician" Publishing Company).

The cost of treating earth with radio-active residues would not be very great—perhaps £1 or £2 per acre—and the activity should remain almost indefinitely, as radium has an average life period of 2500 years. As far as has been ascertained, the treated soil need only penetrate a few inches down, that is, only the upper layer would have to be radio-active.

The effect has been observed on tomatoes, which were found to ripen more quickly, and to be very sweet in character. This increase of sugar seems to be a particular effect of any stimulation by electric or similar means.

Electrifying Animals. The beneficial effects obtained with the human subject have been already experienced by animals, and it was reported two years ago that some ewes fed on land treated with overhead currents, in the manner already described in connection with crops, produced nearly double the number of lambs during one season. This work does not appear to have been confirmed by any subsequent experiments, but the intensive cultivation of fowls by electrical means has proved a great success.

Wonderful Results with Chickens. The current is applied to the young chickens from the first day they are hatched, by means of a large coil of wire wound round the chicken-house. In the experiments now being conducted at Poole, on Mr. Randolph Meech's chicken farm, the young birds are cultivated in what are termed flats, six flats being built one above the other, and seventy-five chickens being grown in each. The whole house thus holds 450 birds. The wire is wound round the house in the form of a helix, the turns being some six or eight inches apart. This coil is connected with a special type of high frequency apparatus, and the currents applied to the chickens for a few minutes each hour during the day.

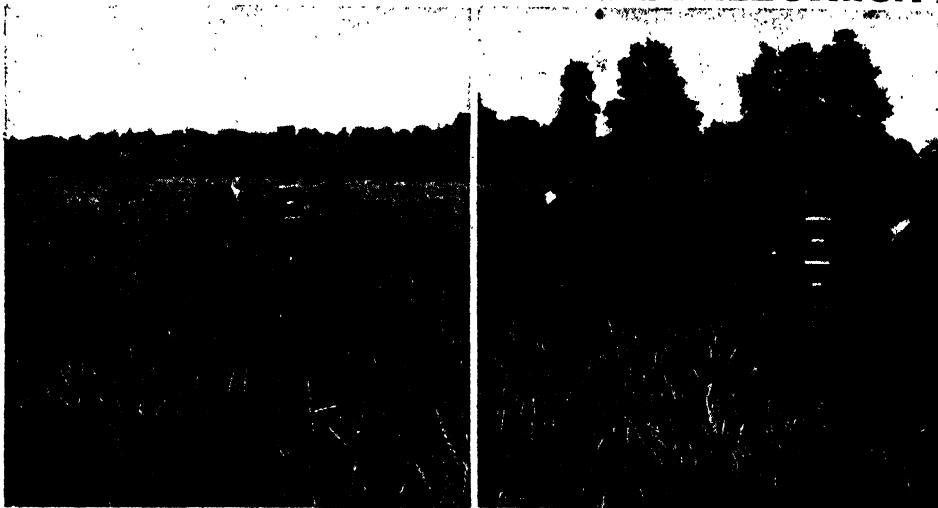
There is, as is well known, great mortality among the young birds for the first three weeks after they have left the incubator—sometimes more than 50 per cent. of them die. One great feature of the electrification is that this mortality is practically overcome. The young birds grow their second feathers in about two weeks, and in from five to eight weeks are ready for sale for the table as "petits poussins," fetching often as much as 2s. per bird.

The wonderful vitality of the little birds makes them easy to rear, and they are now being grown electrically at the rate of 1500 at a time.

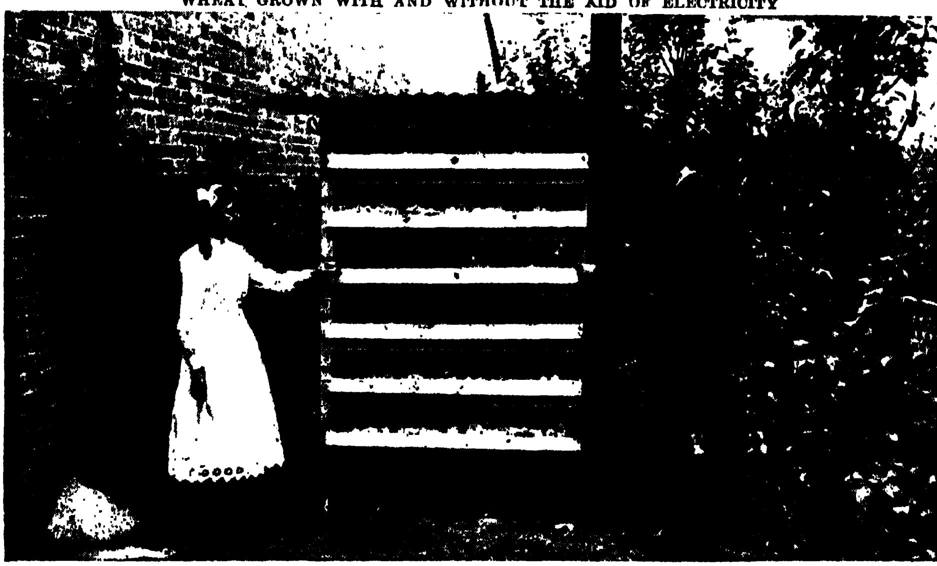
Interesting tests are also being carried on to determine whether the laying of hens can be accelerated by treating them with electricity. An immense field has been opened up as the result of the last two years' work with chickens; and electric stimulation appears to be likely to solve the present uncertainties of intensive cultivation.

T. THORNE BAKER

CORN AND POULTRY IMPROVED BY ELECTRICITY



WHEAT GROWN WITH AND WITHOUT THE AID OF ELECTRICITY



REARING POULTRY WITH THE AID OF ELECTRICITY

CHICKENS IN AN INCUBATOR

OVERHEAD ELECTRIFIED WIRES AT AN EXPERIMENTAL STATION

Commercial Recovery of Oxygen. Oxygen and Life.
The Atmosphere. Ozone. The Function of the Sea.

OXYGEN AND OTHER GASES

Oxygen and Air. We must now make a systematic study of the most important element. We have mentioned it several times for purposes of illustration. If we were to adhere strictly to our treatment of the elements in groups, we should have to consider oxygen and sulphur together. These two elements have considerable resemblances to one another, and should therefore always be associated in the mind of the student. But oxygen is so supremely important, both as an ingredient of the air and in its relation to life, that it must always dominate our thoughts.

As the reader already knows, it is a gas. It was first discovered by Priestley and Scheele and Lavoisier about 140 years ago; its atomic weight we call 16, and it is thus slightly denser than air, of which it constitutes about one-fifth. It may be prepared in small quantities by Priestley's method of heating the red oxide of mercury, or it may be turned out of water by means of chlorine, or may be obtained from its various compounds by means of electrolysis.

Nowadays, oxygen has attained considerable commercial importance. Since the process of combustion, or combination with oxygen, occurs more rapidly and produces more heat in the presence of pure oxygen than in the presence of air, the element is very frequently used in its pure form in many metallurgical operations It is also largely used in order to produce the brilliant light which is given out by superheated lime and which is called limelight. Its use in this connection has already been explained. Furthermore, pure oxygen is now extensively used in medicine, for there are a large number of diseased conditions in which the inhalation of this gas in its pure form, instead of its ordinary inhalation diluted with nitrogen in the air, is of the utmost value. Hence it has become necessary to acquire some means of obtaining large quantities of oxygen as cheaply as possible.

Brins' Process. The most important of the commercial processes is known as Brins', and is easily explained. The oxide of barium is heated in compressed air to a red heat, and is converted into the peroxide or dioxide, since under these conditions it takes up into itself a certain quantity of the oxygen of the air, the nitrogen of which escapes. Now, when the pressure is reduced, the extra oxygen which has been taken up into the peroxide is liberated again, and can be readily collected. The result of its liberation is to leave behind just the same barium oxide with which the process was started, and so it may go on again and again. Thus, the essential materials for the process are merely air, which has no cost, and barium oxide, which can be used over and over again, and hence the process is exceedingly cheap. The oxygen is stored at a high pressure in a steel cylinder to which a tube can readily be attached, and when a stopcock is turned, the oxygen rapidly escapes. When the cylinder is being used in the sick-room, the noise made by the escaping oxygen is usually sufficient to indicate that it is escaping, but a simple test can be applied by placing a glowing match-end at the mouth of the tube. If the oxygen is escaping, the rapidity of combustion of the match will be so increased that it will immediately burst into flame.

Oxygen is a colourless, tasteless, odourless gas, forming, as we have seen, eight-ninths of the weight of water, more than one-fifth of the volume of the air, and actually more than one-half the weight of the solid matter that forms the crust of the earth. It is the most widely diffused of all the elements. It has been liquefied and frozen by Sir James Dewar.

Oxygen and Life. By derivation oxygen means the acid-maker, and its function in this respect has already been explained, but it might almost as well be called biogen, to indicate that it is the life-maker. Every living thing, without exception, depends for the processes of its life upon a continuous supply of oxygen. This fact is supremely important and must be carefully studied.

The students of living things tell us that there is a universal function which is common to them all and continuous in them all. This is termed *respiration.* There are no exceptions to this rule, though it was at one time thought that there might be certain exceptions. When the great French chemist Pasteur, the founder of the new science of bacteriology, came to consider the conditions under which bacteria, or microbes, as he called them, grow, he found that they could be divided into two great groups—those that required air for their life, and those that required absence of air for their life. The first he called ærobic, and the second anærobic. At first this looks as if the microbes belonging to the latter group were an exception to our general rule, for it is the presence of free oxygen in the air that arrests their growth; but it was soon found that unless compounds containing oxygen be present in the materials in which these microbes grow, they immediately die outright. Though they cannot live in air, they cannot, on the other hand, live except in the presence of compounds containing oxygen, which they take from these compounds, thereby, of course, decomposing them. Hence it is true to say

that there are no exceptions whatever to the universal rule that oxygen is the life-giving element. There is also the fact that in every kind of living matter, without exception, oxygen is invariably and necessarily found. It is a constant constituent of protoplasm, the "physical basis of life." It is found in proteids and carbohydrates, afterwards to be studied; and though it is not a necessary ingredient of fats, yet it is invariably a constituent of the living part of the curious animal cells in which the globules of fat are stored.

Oxidation and Reduction. Now, the process of combining oxygen with any substance is called oxidation, and the process of removing oxygen from any substance that already contains it is known, as we have briefly noted already, as reduction. Changes in these respects occur in a vast majority of all chemical processes, and hence these two words are of the utmost importance and convenience in chemistry.

Henceforward we shall use them freely, and assume that the reader is familiar with them. He might expect that the opposite to oxidation would be deoxidation, and that word is sometimes used, but the much more frequent use of the word "reduction" gives some indication of the importance of this element.

Chemistry of Respiration. Now let us look a little further into the question of the oxidation of living matter, which is the object of respiration. The products of this oxidation are extremely simple, and consist almost entirely of carbon dioxide (CO_2) and water (H_2O). But biological chemistry has discovered an extremely important fact regarding this process of oxidation. If we consider an ordinary speck of dead oxidisable material exposed to the action of the air, we find, as we might well expect, that it is its outside or its surface which first shows signs of oxidation; the central part of the material can only be oxidised when all the outside is crumbled away in the form of oxide. But the case is profoundly different when we come to consider a particle of living matter similarly exposed to the air.

Its respiration by no means consists of a mere oxidation of its surface. What happens is that, in some way which we are yet far from understanding, the oxygen is taken up into the very substance of the living matter and then disposed of. But the reader must not imagine that the means by which human beings breathe is an illustration of this fact; we are referring not to that obvious breathing but to the real breathing which occurs when the oxygen is brought into contact with the living matter.

What we are attempting to describe is true of every living cell, no matter whether it be a cell of one of your muscles to which your blood is now conveying some oxygen just derived from the lungs, or whether it be such another living cell as one of the tiny microbes that exist almost everywhere. The point is that the living cell, whether it be an independent organism or merely a humble part of a complex organism such as man, is not at all oxidised by the mere action of oxygen upon its surface, but first of all takes up the oxygen into itself, and distributes it in the most complete and intimate way. This is the fact which we attempt to express when we say that the respiration or oxidation of living things is *intra-cellular*—that is to say, *within the cells*. But we may go further: the facts show that before the process of oxidation actually occurs, the oxygen is actually taken up by the very molecules of the living substance, which, indeed, have the most extraordinary power of retaining it, when necessary, until there may be need for the production of the energy which results from oxidation. Hence we must learn the remarkable fact which is described as the *inter-molecular respiration of living protoplasm*. When the living thing dies, the dead protoplasm, if exposed to air, continues to undergo oxidation. But that is of a very different kind. It is now merely the same oxidation, proceeding according to the ordinary physical laws of inorganic nature, that is seen when the surface of any ordinary metal becomes dulled by superficial oxidation.

Oxidation and Growth. We must not be misinterpreted as stating that the laws of physics and chemistry are not applicable in the world of life: we are merely insisting that there is a profound difference, which we are as yet very far from understanding, between the processes of oxidation that may be observed anywhere, and those infinitely more subtle processes of oxidation which are the essential part of the vital function called respiration. The wise reader will compare the facts upon which we have been trying to insist, facts which enshrine a root principle of the growth of all living things, with the growth that appears to take place in some non-living bodies. Crystals of sugar-candy on a string do increase, but the growth takes place by the addition of layers to the exterior, the interior remaining unaltered.

He will see that this is a profound distinction, strictly consistent with the distinction which we have been trying to state here. He will guess that the reason why the living thing, unlike the crystal, can grow from within is the fact that it is able to undergo chemical changes, largely consisting of oxidation, within its very substance, and resulting not merely in the "growth" of crystals of sugar-candy on a string, but the true growth which implies development and the accomplishment of a purpose. It is its power of ensuring and directing intra-molecular oxidation that enables the living cell so to distinguish itself.

Ozone. When electric sparks are passed through oxygen there is formed the allotropic modification of it which is called ozone, and which has already been described [page 961]. Its formula, we may remember, is O_3; and, in confirmation of this statement, it may be noted that three volumes of oxygen have been proved to form two volumes of ozone, as one would expect, remembering the equation for the conversion of oxygen into ozone already given, and the remarkable law of Avogadro, that equal volumes of gases at an equal temperature

and pressure contain equal numbers of molecules. Ozone may not only be produced by the method above stated, but also during electrolysis, and, in small quantities, in the course of very slow oxidation processes, as, for instance, that which occurs when ordinary phosphorus is exposed to the air. At sufficiently low temperatures ozone is transformed into a bluish liquid, closely resembling liquid oxygen. Ozone is, perhaps, the most inconstant of all the ingredients of the atmosphere. This is due to the fact that it is extremely unstable, for reasons that have already been fully explained. A sufficiently keen nose may recognise its peculiar odour, if its possessor goes out, for instance, into a very pure country atmosphere at night, after spending an hour or two in a smoky or badly ventilated room. In the open country, and at the seaside, ozone may readily be detected in the atmosphere; but wherever there is a quantity of oxidisable organic material in the air—as, for instance, in towns and in their neighbourhoods—ozone is not to be found, since it is decomposed, and ordinary oxygen formed by the reducing action of such organic matter. In all probability ozone cannot be breathed, and is as irrespirable as if it had nothing to do with oxygen. The public generally believes that it is a good thing to breathe air containing ozone; so it certainly is, but not in the smallest degree for the reason that the ozone is of itself of any value as a gas to breathe, but because its presence in air is *a proof that the air is pure*, the simultaneous presence of organic dirt (gaseous or other) and of ozone in air being impossible, owing to the great activity of this gas as an oxidising agent. Various medical experiments have been made in order to test the utility of ozone, and the statements above made may be regarded as accurately summing up the general conclusions to which those experiments lead. In cases of illness there is often very good reason to increase the percentage of oxygen in the air that the patient breathes, but the intentional addition of ozone to it is unnecessary, and depends on an incorrect explanation of the superiority of sea to town air. As we have observed, the presence of ozone in the former is of value, not in itself, but as an index and proof of purity.

The Atmosphere. By far the most important constituent of the atmosphere, from our point of view, is oxygen, though about four-fifths of it by volume is composed of nitrogen: the percentage of carbon dioxide is ·04. In addition, there is always a certain amount of water vapour, and traces of various compounds containing nitrogen. Until late years the foregoing would have been, more or less, an adequate account of the chemical composition of the air, but it is now known that the air contains a number of other gases which are of very considerable interest. If the air were a compound, the presence of these gases must have been detected long ago; but since the air is not a compound, but merely a mixture of gases, it is easy to understand how the presence of these recently discovered gases, which occur in only very small quantities, came to be overlooked.

The Discovery of Argon. The initial discover ywas made by Lord Rayleigh, who has recently served a term as President of the Royal Society. In discussing this very interesting subject we shall follow very carefully the statements and, where possible, the actual words, of Lord Rayleigh himself. He was led to the now universally admitted discovery of the new gas *argon* in the course of some investigations regarding the densities of the most important gases—hydrogen, oxygen, and nitrogen. He found that different results were obtained by different methods of experiment, and it became apparent that the differences were not due to accident or errors of observation, but, as he says himself, "that the complication depended upon some hitherto unknown body, and probability inclined to the existence of a gas in the atmosphere heavier than nitrogen and remaining unacted upon during the removal of the oxygen." This was the means by which Lord Rayleigh, with the aid of Sir William Ramsay, the Professor of Chemistry at University College, London, was enabled to announce to the British Association in 1894 the discovery of a new gas in the atmosphere, though "for more than one hundred years before 1894 it had been supposed that the composition of the atmosphere was thoroughly known." This new gas was named *argon*, which is a Greek word meaning lazy, in order to indicate the fact that it is chemically very inert and has no tendencies to unite with any other substance. This chemical inertness of argon is, of course, one of the reasons why it was so long in being discovered. It is, perhaps, worth noting that certain chemists inclined to the view that argon is a sort of condensed nitrogen having the formula N_3, just as ozone, with the formula O_3, is a sort of condensed oxygen. But that view is entirely disproved. Argon is unquestionably an element, and possesses a very characteristic spectrum [see PHYSICS]. Its atomic weight, according to various investigations, is very nearly 40. So inert is this element that there is still no definite evidence of the preparation of any compound of it whatever, despite a very large number of attempts to produce such combinations.

More New Gases. This discovery, however, like so many others that have been at first questioned, has not only been established, but has led to many more, which stand to the credit of Sir William Ramsay. Argon, so long unknown, actually constitutes nearly one per cent. of the atmosphere. Contrast this with the tiny proportion of carbonic acid. But there have now been isolated from the original argon, so to speak, no less than four other elements, and probably five. The four of which we may be certain are called *neon* (Greek for new), *krypton* (Greek for hidden), *xenon* (Greek for stranger), and, by far the most interesting of all, *helium*, the name of which is derived from the Greek word for the sun, and was given it for the reason that, as we already noted [page 1094],

this most remarkable element was discovered in the sun before it was found on the earth. Helium must be discussed at a much greater length when we come to consider a still more remarkable element, *radium*. The percentage of these gases in the air is extremely minute, and, according to Sir William Ramsay, probably the volume of all of them taken together does not exceed $\frac{1}{400}$th part of that of the argon. Now, the remarkable fact which is common to all these five new constituents of the atmosphere is that not one of them can be made to combine with any other substance whatever—in fact, they are all as "lazy" as argon. Each of them has its own characteristic atomic weight and spectrum, but we need not concern ourselves with these. The really interesting thing is the existence of these five elements, which seem, so to speak, to be isolated in Nature; more especially because we have reason to believe in a *periodic law* which declares that all the elements are related to one another.

The New Gases and the Periodic Law. Now, one of the most important facts which are demonstrated by the periodic law is that the succeeding groups of elements show a regular progression in the number of atoms of other elements with which one of their own atoms is able to combine. This property is called *valency*, and will be considered later. For instance, group one of the elements includes those whose atoms are able each to unite with one atom of any other similar element. Hydrogen and sodium, for instance, belong to this group, and are hence called monovalent—that is to say, their valency is *one*. Oxygen, again, belongs to the second group, and its valency is *two*. The best illustration of what is meant is furnished by the formula of water, which is H_2O, indicating that it needs two "one-handed" hydrogen atoms, so to speak, to unite with one "two-handed" oxygen atom. This is enough to enable us to understand valency so far as we need at present. Now, what is to be done with a group of elements which are incapable of combining at all—elements which have no valency? Plainly, if the periodic law be correct, they must form a group nothing, or zero, which must fit into the table with all the other elements. Now that is exactly what, indeed, these elements do: directly we discover their atomic weights, we find that they naturally fall into the very places which theory would have predicted for them, and they formed the *zero* group of the late Professor Mendeleeff's table, published ten years ago.

For a consideration of a large number of other important facts concerning the atmosphere, the reader must consult the course on Physics. There is little more of importance to be said concerning the chemistry of the atmosphere, though very much that is a matter of life and death might be said if we were discussing the subject of ventilation [see PHYSIOLOGY and HEALTH]. The necessity for ventilation depends upon the fact that the presence of living things in the atmosphere alters its composition to their disadvantage, so that, if they do not move to fresher air, fresher air must be brought to them to enable them to live.

The History of the Atmosphere. If we recall the teaching of geology and astronomy, telling us how the earth was once too hot to sustain life, we shall see that the mixture of gases that covers the solid surface of the earth, and that we familiarly call the air, must have had a very interesting history. According to one widely accepted theory of the earth's origin, all that we now know as the solid earth, and all the liquid matter that now fills the ocean-beds, was once gaseous. The gases of the atmosphere are simply composed of those particular elements which are gaseous at the present temperature of the earth's surface, which have not entered into complete combination with the solid matter of the earth's crust, and which have not been whisked away into space by centrifugal force [see PHYSICS], this being the fate that is supposed to have befallen the former atmosphere of the moon, and some of the lighter constitutents of our own atmosphere. Now, in the past, when the earth's temperature was much higher, and when many other conditions were different, it is more than probable, for instance, that—long before man appeared—the proportion of carbon dioxide (CO_2) in the air was much higher than it is at present. This would account for the extreme luxuriance of vegetation, to which every lump of coal bears witness, the carbonic acid of the air being one of the most important constituents of the food of plants. Again, it is quite certain that, at a very much more remote period, which must certainly date back tens of millions of years, the temperature of the earth's surface was so hot that water could not occur in its liquid form. At that time one of the most important and abundant constituents of the earth's atmosphere was gaseous water, or water vapour.

The Future of the Atmosphere. Whatever the past history of the atmosphere may have been, we can scarcely fail to be interested in the question of its future, upon which the continued existence of the human race certainly depends. It seems at first sight quite evident that there is taking place a very serious, though admittedly very slow, change in the chemical composition of the atmosphere, depending upon the respiration of the countless living things, animal and vegetable, which depend upon it for their life. What is continuously happening day and night in the case of every living thing, without exception, including, for instance, the writer as he forms these words? His body is undergoing a series of chemical interchanges with the atmosphere, the essential upshot of which is that the air around him becomes poorer in oxygen and richer in carbonic acid. Now this process of respiration and its consequences are common to every living thing, always and everywhere. Hence there appears to be no choice but to believe that the percentage of carbonic acid in the air is slowly increasing, and that of oxygen slowly diminishing. Meanwhile, the students of health remind us that when the percentage of carbonic acid in the air goes anywhere above ·06 such air becomes more or less

poisonous to animal life in general, including the life of man. Are we then to believe that the carbonic acid is accumulating, and will continue to accumulate, gradually filling up the valleys and low-lying districts in consequence of its greater weight, and gradually driving human beings higher and higher, until the "last man," gasping for air on some mountain peak, joins his fellows who lie drowned in the sea of carbonic acid beneath him?

A Compensatory Action. Now, in the first place, we must notice that there is a compensatory action, which is of considerable importance—namely, the action of the green plant, under the influence of sunlight, in decomposing the carbonic acid of the air, retaining the carbon and giving back to the air free oxygen again. This process, however, cannot suffice to dispose of the picture we have suggested, even apart from the fact that its value is largely neutralised, since even the plants that perform this function are also necessarily performing the opposite function of respiration. There is another fact of the very greatest importance, which is of only comparatively recent discovery, and which is of great importance to the theorist, and of incalculable importance in relation to the future of the atmosphere.

A Function of the Sea. In a previous chapter we briefly noted, in reference to the existence of double compounds, that the many salts of sea-water exist in a somewhat peculiar state. If we take a sample of sea-water and proceed to analyse it according to the usual methods, we find that it contains such and such a percentage of sodium chloride, another percentage of salts of magnesium, and so forth. Hence, we might suppose that these salts exist in definite form, and in definite proportion in sea-water; but it is not so. We know now that the salts of sea-water mainly occur, not at all in definite states, but in states which constantly vary and differ, according to the physical conditions—conditions such as the temperature, the pressure of the atmosphere, the partial pressure of the various gases in the atmosphere, and, indeed, all the other physical conditions that occur. It is the new science of what is often called *physical chemistry* that is teaching us how exactly to correlate such physical conditions with the facts of chemical combination and union.

Now, if the reader remembers our former discussion of the carbonate and bicarbonate of calcium, and the formation of stalactites and stalagmites, he is already completely prepared to understand the most important function of the sea in regard to the composition of the atmosphere. He will remember how an extra proportion, so to speak, of carbonic acid is sometimes added to carbonate of calcium, converting it into the soluble bicarbonate, and how, under certain physical conditions, such as occur when water, charged with bicarbonate, drips through the roof of a cave, the extra carbonic acid is given off to the air, and the insoluble carbonate is precipitated or solidified from out of the water. Now, a parallel series of changes occurs in certain carbonates of sea-water, more especially the carbonate of magnesium. In sea-water there occurs a certain amount of this salt in a more or less stable state, and also a certain quantity of the bicarbonate of magnesium.

But, as we have already seen, there is reason to believe that the proportion which these two salts bear to one another in sea-water depends strictly upon the physical conditions which surround them, the most important of these conditions being the percentage of carbonic acid in the air above the sea [page 1362].

There is thus an automatic, self-regulating mechanism by which the oceans are enabled to preserve the constancy of the proportion of carbonic acid in the air above them, and not only so, but the winds, and that property of gases which we have described as diffusion [see PHYSICS], ensure that the consequences of this process extend also to the air of the land. Of course the discovery of this process is very far from enabling us to reach any positive conclusions as to the more immediate future of the atmosphere. It is evident that the mere absorption (in the form of bicarbonates in sea-water) of the extra carbonic acid which is being constantly added to the atmosphere by the respiration of all living things, and also by every kind of combustion initiated by man for his own purposes, is by no means equivalent to an absolute compensation for this process. All that it accomplishes is to hide the consequences of the process or postpone them.

Tendency of Chemical Change. There is thus raised the further question, which cannot be considered here, as to the ultimate consequences of the fact that the overwhelming tendency of all the chemical processes that occur on the earth is in *one direction*—a direction which is well indicated by the union of carbon and oxygen to form carbonic acid. The essential consequence of this union is the dissipation of the potential chemical energy [see PHYSICS] of the carbon and of the oxygen in the form of heat energy or kinetic energy, which is scattered and, for practical purposes, lost, though, of course, it is not annihilated. Hence, in considering the future of the atmosphere, we are led on to the study of the remarkable and vastly important theory called by its author, Lord Kelvin, the theory of the *dissipation of energy*.

So much, then, for our chemical discussion of the atmosphere, of which, from our point of view, the oxygen is the essential constituent, the carbonic acid a source of some apprehension, and the large proportion of nitrogen merely a means of diluting the oxygen, which would otherwise be too active for our convenience. We have now to remind ourselves that, when the elements are considered in groups, there is good reason for considering sulphur and oxygen together, and we must therefore pass on to discuss this other important element.

C. W. SALEEBY

Justinian and his Code. The Growing Pressure from Mohammed's Followers upon the Eastern Empire.

EARLY MIDDLE AGES IN THE EAST

DURING the fifth century the Roman Empire in the East had enjoyed a comparative, but only a comparative, immunity from the chaos in Italy and the West. Then, after the line of Theodosius had come to an end, a captain named Justin, who is commonly reputed to have been of Slavonic blood, was raised to the purple. With himself he associated his exceedingly able nephew, Justinian, who succeeded him in 527, about the time of the death of Theodoric, in Italy.

It was the intention of Justinian to re-establish his authority over the whole empire. His great general Belisarius, who had first distinguished himself by brilliant services against the advancing Persians in the East, almost destroyed the Gothic power in Italy, though the completion of that work was left to be accomplished by Narses. Belisarius also annihilated the Vandal kingdom in Africa, of which the world was very well rid. At the end of his life he repelled the vigorous attack on Constantinople of a new horde mainly of Mongol origin.

Justinian, in fact, exhausted his resources in wars which were unnecessary, if successful, and in vast public works, which were splendid but needlessly extravagant. His fame, however, rests chiefly and deservedly on his great work codifying and giving a permanent shape to the vast mass of laws and precedents which the Roman legal system had been accumulating for many hundreds of years. The code of Justinian became the basis of law practically in every European country, with the one notable exception of England.

Save for the destruction of the Vandals, neither the empire nor the world derived much benefit from Justinian's victories. The destruction of the Gothic kingdom in Italy only made easier the advance of other Teutonic races, the Franks and the Lombards, whose civilisation was infinitely behind that of the Goths; while after Justinian's day the officers of the eastern empire were never able to exercise any effective control over the west.

The really imminent danger was from the Persian power, which became extremely aggressive. The Persians overran all Western Asia, conquered Syria and dominated Asia Minor, until the line of Justinian came to an end, and the imperial succession was secured, about 610 A.D., by the great soldier Heraclius, who after long preparations fell upon the Persians like a thunderbolt, and completely broke up their power in a series of brilliant campaigns. But, even while he was delivering the Western world from this Oriental peril, a storm-cloud was arising in a new and most unexpected quarter.

The wild tribes of Arabia had always stood outside the influence of the neighbouring civilisations, Egyptian or Syrian, or Greek or Roman. They were still primative nomads or primitive agriculturists. Traditionally, they claimed descent from the father of the Hebrew race through Ishmael, the son of the bondwoman; but their already distorted religion had been further distorted by all sorts of miscellaneous accretions, till, in the sixth century, it was a sort of conglomerate of fetish worship and demon worship, with occasional borrowings from Judaism, Christianity, and miscellaneous Eastern religions. In the city of Mecca were a temple and a stone, called the Kaaba, which were general objects of veneration traditionally associated with Adam and Abraham.

In these very unlikely surroundings arose the prophet Mohammed, who when already of mature years became possessed with the idea that he had a mission of regeneration to accomplish. The archangel Gabriel appeared to him in a vision. He began to preach moral and religious doctrines, by no means elevated, but still infinitely higher than anything to which the Arabs had been accustomed. He was met first with scoffings, then with persecution. In the year 622, he was obliged to take flight

from Mecca; this year of the Prophet's flight, which is called the Hejira, is reckoned as the first year in the Mohammedan era, the equivalent of A.D. in the Christian era.

But the Prophet found followers; they grew in numbers; their leader claimed, and they believed, that his pronouncements were inspired. They made war upon the unbelieving city of Mecca; they were victorious over the Meccans; and the Kaaba was converted into the sacred shrine of the new faith. The Prophet and his followers set themselves to compel submission to his authority at the sword's point. When the Emperor Heraclius was engaged in his struggle with the Persians, both he and the Persian king received missives inviting them to recognise the Prophet of Allah—missives which the Persian received with contumely and Heraclius with polite but hardly veiled contempt. Neither of them imagined that an obscure Arabian fanatic was about to turn the world upside down.

The Spread of Islam. All Arabia embraced Islam, "the Faith." Mohammed's death was a shock to his followers; but the ablest of his disciples, Abu Bekr, was chosen as the first khalif, or successor of the Prophet. Rivals naturally sprang up; they were vigorously suppressed, but the faith which had first established itself by the sword was fanatically resolved to spread itself by the same means. The Moslems, organised after Abu Bekr by the great Omar, advanced against the West and against the East, offering to all opponents the three alternatives, conversion, submission and tribute, or death. The first energies of Islam were directed against the Persians; its arms were carried across the Euphrates and across the Tigris. Following this eastward advance the Moslems turned upon Syria, which was a portion of what was still called the Roman Empire, absorbed it piecemeal, burst upon Egypt, and in 641 captured its capital city, Alexandria.

JUSTINIAN PRESENTING HIS CODE OF LAWS TO TRIBONIAN, HIS MINISTER

The progress of Mohammedanism was as rapid in Africa as it had been in Asia; in no part of his dominions oversea could the emperor from Constantinople offer an adequate resistance. Physically and intellectually he was no longer the same man who had hurled back the Persian power. After his death, his successors proved to be no better able to deal with the situation. Outside of Europe little remained to the empire except Asia Minor. The Saracens, as the followers of the Prophet began to be called, built fleets which dominated the Mediterranean, carried their faith westward among the Berber tribes on the African coast, flung themselves even upon Sicily, and in the beginning of the eighth century threw an invading force into Spain, where the Gothic power was destroyed, the Goths were driven into the north-western and north-eastern corners of the peninsula, and the Moslems ruled supreme over the rest. Thence they broke into France, and their career was only stayed by the decisive victory of Charles Martel, at Poitiers.

The Internal Dissensions of Islam. The khalifate, the leadership of Islam, had fallen into the hands of a family called the Ommayads. Under them the Saracen dominion had been extended over the whole East to the further confines of the Persian empire; Arab invaders early in the eighth century planted themselves even in the Punjab, though they established no permanent dominion in India.

The house of Heraclius had failed to defend Africa and Asia east of the Taurus mountains against the Moslem deluge. Nevertheless, Constans, the grandson of Heraclius, fought manfully against the Saracens, and at least held them in check, though he failed to recover lost territory. The vigour of their attack was indeed weakened by internal dissensions among the faithful, and struggles for the khalifate. A great body amongst the Moslems maintained that the true succession lay with the house of Ali, the son-in-law of the Prophet, husband of his daughter Fatima. This section came to be variously known as the Shiites or Fatimites. During the third quarter of the seventh century the attack upon the West was consequently relaxed.

The Saracen Occupation of Asia Minor. Constans then, not very wisely, turned his attention once more, with some degree of temporary success, to an attempt at recovering supremacy in Italy. While he was in the west, the Saracen attack was renewed. Constans was assassinated, and was succeeded by his young son Constantine, called Pogonatus, the Bearded. So vigorous was the onslaught that the Saracens pierced the Taurus, overran Asia Minor, and

JUSTINIAN THE BYZANTINE AND HIS COURT

THE EMPEROR JUSTINIAN AND HIS ADVISERS IN WAR AND PEACE

THE EMPRESS THEODORA WITH THE PRIESTS AND LADIES OF HER COURT
From the celebrated mosaics of contemporary date at S. Vitale, Ravenna

threatened Constantinople itself. The victory, however, fell to Constantine, who first succeeded in shattering the enemy's fleet, and then inflicted upon their land forces a rout in which thirty thousand of them were said to have been killed.

Slavonic Occupation of the Balkans. At about this time the Mongol Bulgars effected their definite settlement in the Danube valley. Slavonic tribes, also, of the Aryan stock had for a long time past been spreading themselves over the whole of the Balkan peninsula. The Mongol Bulgars dominated, and gave their name to Bulgaria; but, in fact, the Mongol stock soon mingled with and became absorbed in the Slavonic stock, so that even from a very early stage the Bulgarians must be looked upon not as Mongols but as Slavs.

Though Constantine drove the Saracens back out of Asia Minor, he was unable to carry a counter attack beyond the Taurus. On his death in 685, he was succeeded by his son, Justinian II., a prince whose remarkable abilities were counterbalanced by ungovernable passions and a singularly cruel and capricious disposition. He was dethroned and driven into exile in consequence of his misdeeds and violence; nevertheless, he was able to return after a time and recover his throne by the aid of the Bulgar king. His tyranny, however, could not be tolerated for many years. He was killed in a military revolt, and once more there was a brief succession of emperors, raised to the purple by one military faction, only to be overthrown by another.

Saracen Advance on Constantinople. The vigorous Velid became khalif in 705. Under his rule the power of the khalifate increased; but though the troubles at Constantinople enabled his troops to overrun Asia Minor, his main energies were directed to establishing his power in the further East. In 715 he was succeeded by Suleiman, and Suleiman determined to make a grand attack upon the Christian empire at Constantinople.

The first onslaught was checked at Amorium, in the centre of Asia Minor, by the imperial general Leo, called the Isaurian—the Isaurians being a race of mountaineers of Eastern Asia Minor. But Leo saw that the Saracens were not to be held back by the struggles of isolated generals. The chaos at Constantinople must cease if an organised resistance was to be offered. From Amorium he hurried to Constantinople, where the last emperor who had been raised to the purple was wise enough to abdicate voluntarily in favour of a man able to deal with the situation. Leo was acclaimed emperor, and at once set about a vigorous organisation of the defences of Constantinople.

The Saving of Eastern Europe. The armies of Suleiman poured across Asia Minor; his fleet dominated the Ægean Sea; his troops were carried over to Europe, and Constantinople was shut in upon the west as well as upon the east. But through the winter Constantinople defied attack, and Leo's ships, issuing from the Golden Horn, broke up the Persian fleet. As the spring of 718 advanced, the Bulgarian king was induced to lend his aid. He attacked the Moslem force on the west, and inflicted upon it a great defeat. Leo himself had by this time dealt a heavy blow to the forces on the other side of the Dardanelles. The Saracens in Europe were already in straits from failure of supplies. The siege was raised; the remnants of the army were embarked on the fleet, and most of the fleet went to the bottom in a storm. Leo's defence of Constantinople saved Eastern Europe as decisively as Charles Martel saved Western Europe fourteen years afterward at the battle of Poitiers. Thenceforth the question became rather one whether the Greek empire would recover territories beyond the Taurus than whether the khalifate would encroach any further upon its borders.

Bagdad as a Seat of Culture. For some years vigorous emperors ruled at Constantinople, while the Saracen empire was again torn by factions. About the middle of the century the Ommayads in the east were completely overthrown, and a dynasty of khalifs called the Abbasides was set up. One of the Ommayads, Abd er Rhaman, escaped, and was recognised as khalif in the west; but the eastern khalifate remained with the Abbasides, who set up their capital in the city of Bagdad, on the Tigris, which grew rapidly in wealth and splendour. Here, in 786, began the reign of the famous khalif Harun al Raschid, whose name was surrounded by almost as many myths as that of his mighty contemporary Charlemagne. At this epoch of the world's history the centre of culture, of learning, of wealth, and, it may be added, of toleration, was to be found not at Constantinople nor at Rome nor at Aachen, but at Bagdad.

The Rise of the Iconoclasts. Leo the Isaurian is famous not only for the great and decisive repulse of Islam. He was also the founder of the dynasty known as the Iconoclasts. Both in Eastern and Western Christendom Christianity had been overlaid with gross superstitions. Leo, in other respects orthodox enough, had learnt, perhaps from contact with the Mohammedans, to abominate idol worship; and superstitious adoration of relics genuine or spurious and of the effigies of the saints appeared to him to be nothing less than idolatry. He and his successors set themselves to the suppression of the worship of images, and hence came their title of the Iconoclasts, the "image-breakers." The ecclesiastics and the uneducated populace resented what appeared to them to be a blasphemous heresy; and throughout the century the struggle raged between the two parties who were known respectively as the Iconoclasts and the Iconodules.

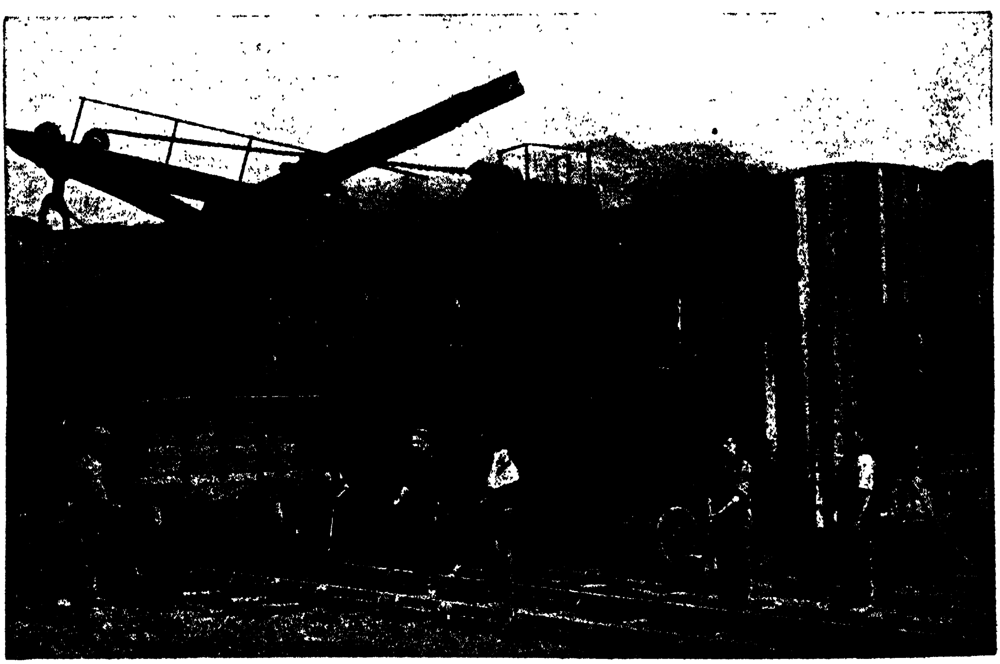
The Iconoclasts were strong and capable rulers, and the eastern empire flourished under their control, in spite of religious dissensions and persecutions. The dynasty, however, was brought to an end at the beginning of the ninth century, when the imperial power had been usurped by Irene, the mother of the man who should have been emperor.

A. D. INNES

THE ENTRY OF THE VICTORIOUS PROPHET IN MECCA

MACHINES THAT SCOOP OUT THE EARTH

1. A STEAM CRANE EXCAVATOR AT WORK



2. AN ELECTRIC NAVVY AT WORK ON A RAILWAY CUTTING

Machinery for Cuttings, Trenches, Tunnelling, Rock-Cutting, Dredging, and Pumping. Locomotives, Tip Waggons, and Dobbin Carts.

THE CONTRACTOR'S MACHINERY

THE machinery and appliances used by a contractor in carrying out works of construction coming under the head of Civil Engineering vary with the class of work and the magnitude of the contract. The contractor has to take the risk of the efficiency of any method he may adopt, and good judgment in the use of means is most essential if he is not to incur an actual loss; but it must be remembered that a contractor's nominal loss is frequently only the loss of further profit that he thinks ought to have been made. The risk is great, and it is only right that the profit should be correspondingly large when good judgment is exercised.

General Tools. The personal tools, such as picks and spades, barrows and wheeling planks, ladders, scaffold boards, blocks and falls, crab winches and crowbars, will always be needed. A portable steam-engine, mortar-mill, stone-breaker, screens and concrete mixer will probably come next, with horses and strong carts for carrying bricks and earth. Then sheds for storing lime and cement, a smith's forge, a saw-mill, a portable office, and, for a large contract, a light locomotive, trucks and rails, steam navvy or portable excavator, pumps, derrick poles, overhead travellers and gantries, steam cranes and pile engines. When any particular piece of plant is wanted for temporary use only, it may generally be hired at a charge of about one per cent. of its value per week, but large contractors find it cheaper to buy outright all the plant they require for use.

Excavating Machines. A navvy's pick and shovel and hand-barrow are only used on the smallest work, and machines have been introduced to economise both time and labour. The majority are of the steam crane type, such as that by Wilson & Co., shown at work on the Cruden Railway, near Aberdeen [1].

This machine has a lifting power of 12 tons, and will excavate and put into waggons 750 to 1000 cubic yards per day of ten hours, according to the nature of the ground. It will work a clear 22 ft. space and drive a gullet 50 ft. wide, turning round the whole circle. By removing a couple of cotters, the digging gear can easily be disconnected, and the machine then becomes an ordinary 12-ton locomotive crane, with free movement for the disposal of the excavated material. Its total weight is about 35 tons.

The latest type of appliance for this kind of work is the electric navvy, shown in 2, and constructed by Ernest Scott & Mountain, Ltd., of Newcastle-on-Tyne.

As the waggons are filled, they are run by horses to the tip, where the material from a cutting has to make up an embankment, or to be put into trains drawn by a contractor's locomotive, where the distance to be travelled is sufficiently great to warrant the additional expense. Tip waggons are generally used so that the unloading is automatic.

Dobbin Carts. Dobbin carts are small, strong tipping carts, containing ¾ yd. of earth, being suitable for drawing by one horse over a rough surface. The following table gives the capacity of various appliances utilised for removing earth:

		CUBIC YD.
A wheelbarrow light	holds	$\frac{1}{18}$
A wheelbarrow, ordinary		$\frac{1}{14}$
A wheelbarrow, large (navvy) ..		$\frac{1}{10}$
A dobbin cart		$\frac{3}{4}$
A one-horse cart (6 ft. × 3¼ ft. × 2⅓ ft.)		$1\frac{2}{3}$
An earth waggon, small, filled to level of sides, as with gravel, sand, etc.		2
An earth waggon, small, when heaped, as with earth or clay		2½
An earth waggon, large, filled to level of sides		2¾
An earth waggon, large, heaped ..		3

Pug-Mills. When clay from an excavation is required for use to form a water-resisting medium, as in reservoir dams or coffer dams, it is put through a pug-mill, to *temper* it or work it up to a homogeneous mass, in which condition, so long as it is kept moist, it is impervious to water.

Sewer Excavators. A novel form of excavator, by the Municipal Engineering and Contracting Co., shown in 5, is used in America for cutting the trenches for laying sewers, gas and water pipes. This machine excavates trenches 14 to 60 in. in width, and any depth up to 20 ft. It is reckoned to do the work of 150 men. Another form of trench excavator, made by Van Buren, Heck & Marvin, and used with success in America, is shown in 4. It is geared to travel at a speed of 2 ft. per minute, and is capable of digging trenches up to 12 ft. deep and 4½ ft. wide. The machine shown in the illustration dug a trench 7 ft. deep and 26 in. wide in stiff clay at a rate of 700 to 900 lineal ft. per day. The trench excavating machine made by the Helm Trench Machine Co., and shown in 3, is of the bucket dredging principle. This machine is capable of digging trenches of any depth up to 25 ft, and any width from 24 in. to 36 in. by changing the buckets.

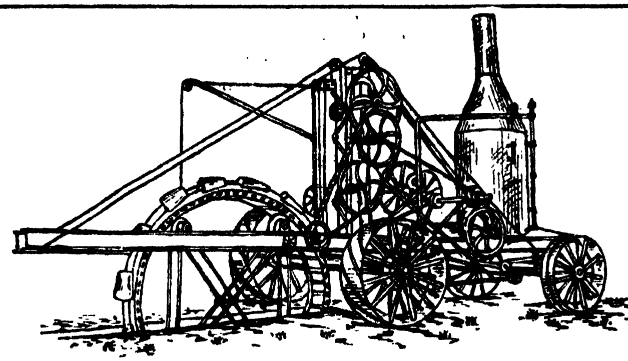
Excavating machinery is, perhaps, the innovation of comparatively recent times that has done more than any other to economise the cost of large contracts. In the formation of canals and railway cuttings, where the soil is suitable,

nearly the whole of the work can be done by a steam navvy, including the formation of the side slopes; and the trench excavators illustrated below may be expected to prove as useful for work in the open country in England as they are in America. For town work, there are many cases where they would not be applicable, owing to gas and water pipes being in the way, and requiring careful hand-digging, to avoid damage.

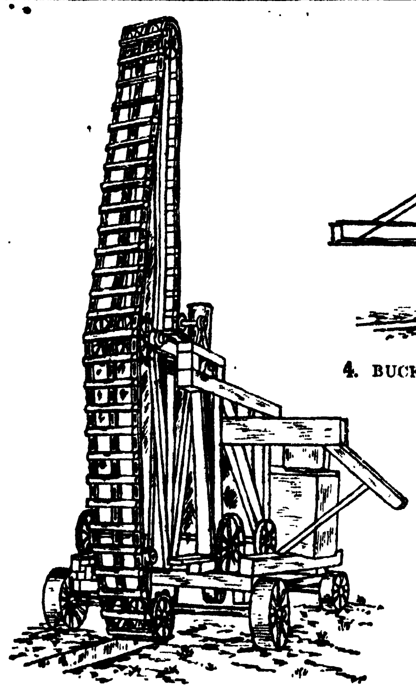
Tunnelling in Clay. Tunnelling in clay is now done by means of the Greathead shield, which is a ring of steel forced forward by hydraulic rams bearing against the cast-iron lining rings, previously fixed. The direction is altered for a curve or gradient by increasing the stroke of the rams on a portion of the circle.

Pumping Appliances. A chain pump, consisting of float boards attached at intervals to a continuous chain, and drawn up a wooden trunk over a wheel at the top, forms a suitable arrangement for dealing with large quantities of water where there may be any straw, chips, or shavings about, as it is not very liable to choke; but when the water is fairly clean, the pulsometer pump [9] is the most convenient and simple appliance.

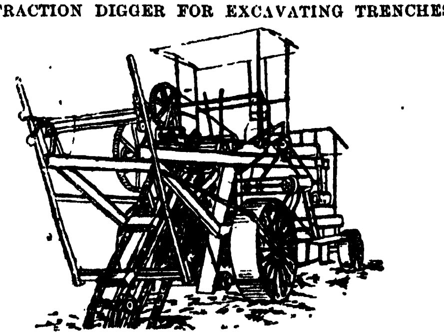
The Pulsometer Pump. The pulsometer shown in section in **10** consists of a single casting called the body, which is composed of two chambers AA joined side by side, with tapering necks bent toward each other, and surmounted by another casting called the neck J, accurately



4. BUCKEYE TRACTION DIGGER FOR EXCAVATING TRENCHES



3. TRENCH EXCAVATING MACHINE



5. SEWER EXCAVATOR AT WORK

The difficulty of driving the small heading in advance of the tunnel proper may be overcome by the use of an electric excavator in front of the Greathead shield, as shown in 7, which is by Ernest Scott & Mountain, Ltd. Gravel is not only harder to drive through than clay, but it is more subject to the influx of water. When this is likely to enter, special pumping arrangements have to be made, and it may even be necessary to work under pressure with an air lock.

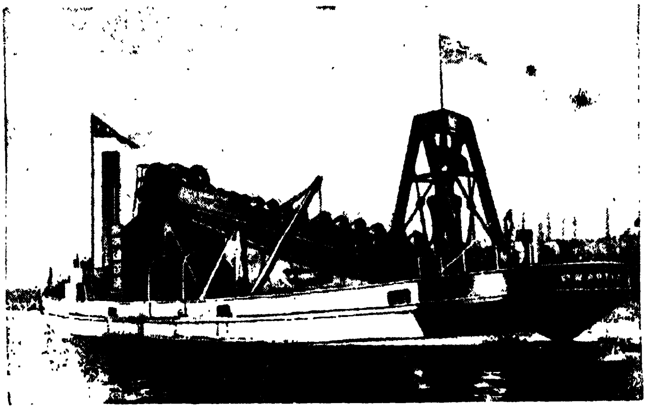
The introduction of this system proved of inestimable advantage in the construction of the tube railways across London; the cost of the work in the old style of tunnelling, with massive brickwork, supported by a forest of timbering, would have been practically prohibitive, and when the difficulties of ventilation were overcome, the great extension of the tube railway system of the last few years naturally followed.

fitted and bolted to it, in which the two passages terminate in a common steam chamber, wherein the ball-valve 1 is fitted so as to be capable of oscillation between seats formed in the junction.

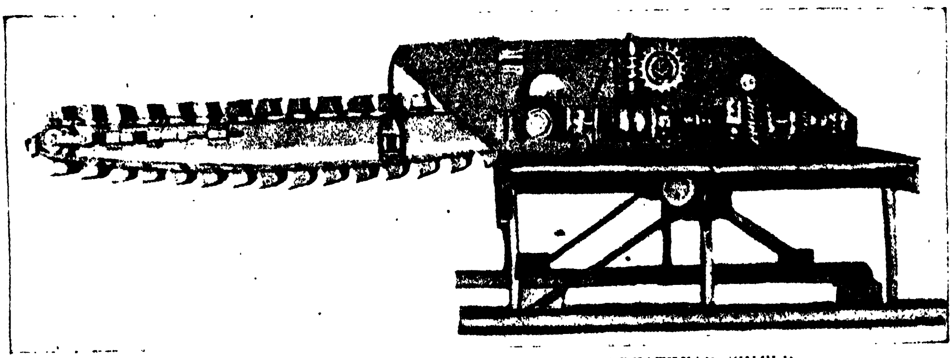
Downwards, the chambers AA are connected with the suction passage C, wherein the inlet or suction valves EE are arranged. A discharge chamber, common to both chambers, and leading to the discharge pipe, is also provided, and this also contains one or two valves FF, according to the purpose to be fulfilled by the pump. The air chamber B communicates with the suction. The suction and discharge chambers are enclosed by hinged covers HH accurately fitted to the outlets by planed joints, and readily removed when access to the valves is required; in the larger sizes, hand holes are provided in these covers. GG are guards which control the amount of opening of the valves EE. Small air cocks are

screwed into the cylinders and air chamber, for use as will be hereafter described. These are the general outlines of the construction of the apparatus, and they are sufficient for the understanding of the nature of its operations.

Action of the Pump. The pump, having been filled with water, either by pouring water through the plug-hole in the chamber, or by drawing the charge, as can readily be done by attention to the printed directions, is ready for work. Steam admitted through the steam-pipe K—by opening to a small extent the stop valve—passes down that side of the steam neck which is left open to it by the position of the steam ball, and presses upon the small surface of water in the chamber which is exposed to it, *depressing it without any agitation*, and consequently with but very slight condensation, and driving it through the discharge opening and valve into the rising main.

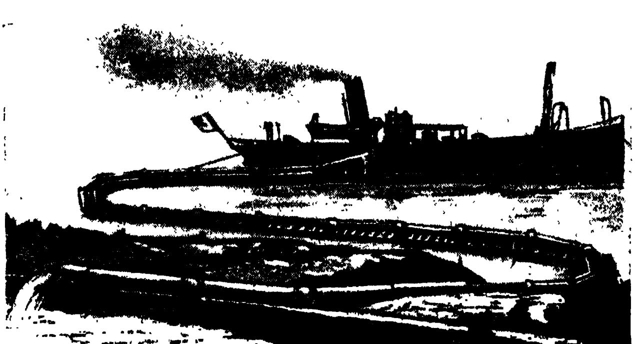


6. BUCKET DREDGER AT WORK



7. ELECTRIC EXCAVATOR FOR USE WITH THE GREATHEAD SHIELD

The moment that the level of the water is as low as the horizontal orifice which leads to the discharge, the steam blows through with a certain amount of violence, and being brought into intimate contact with the water in the pipes leading to the discharge chamber, an instantaneous condensation takes place, and a vacuum is, in consequence, so rapidly formed in the newly emptied chamber that the steam ball is pulled over into the seat opposite to that which it had occupied during the emptying of the chamber, closing its upper orifice and preventing the further admission of steam, allowing the vacuum to be completed. Water rushes in immediately through the suction pipe, lifting the inlet valve E, and rapidly fills the chamber A again. Matters are now exactly in the same state in the second chamber as they were in the first chamber when we began our description, and the same results ensue. The change is so rapid that, even without an air vessel on the delivery, but little pause is visible in the flow of water, and the stream is, under favourable circumstances, very nearly continuous. The air cocks are introduced to prevent the too rapid filling of the chambers on low lifts, and for other purposes, and a very little practice will enable any unskilled workman or boy so to set them by the small nut that the required effect may be produced. The



8. SUCTION DREDGER AT WORK

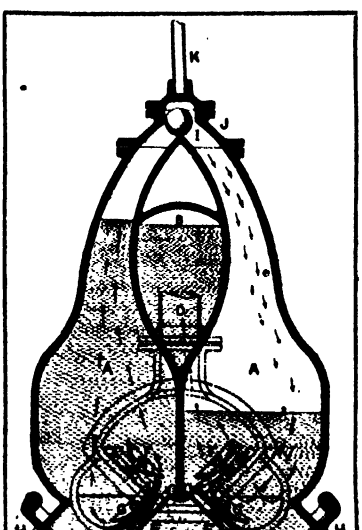
action of the steam ball is certain, and no matter how long the pump may have been standing, it will start as soon as dry steam is admitted. These pumps are largely used by contractors for clearing water from excavations and caissons.

9. PULSOMETER PUMP

Other pumps, such as Bailey's Aqua-Thruster, are made upon the same principle. Their great advantages are simplicity and portability; they can be applied wherever a steam pipe can be led, and can be readily lowered as the water level is reduced.

Rock Cutting. When an excavation or tunnel has to be carried through solid rock, holes are drilled by steam or pneumatic drills or jumpers, such as 11, which is made by the Wood Drill Works, U.S.A. Blasting cartridges are inserted to break away the material in positions suited to the quantity to be removed and the space which has to be cleared.

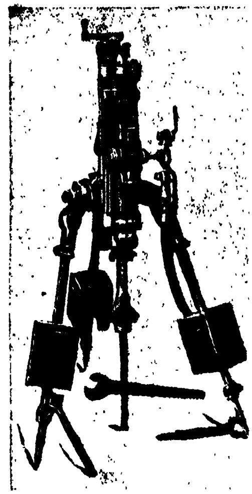
A general knowledge of surface geology is of much use to a contractor in estimating the difficulties he is likely to encounter, but most contractors depend upon their practical experience rather than upon any book knowledge which may be available.



10. SECTION OF PULSOMETER PUMP

An important matter in carrying out engineering work is to utilise the material found on the spot. Such, for instance, as using flints, ballast, or small broken stones for the aggregate of concrete; burning the chalk or limestone for producing lime; using the rough stone for rubble walling, and the better class of stone for block masonry, and so on.

Dredging Machinery. When the material to be removed is under water, suction dredgers [as 8, made by J. H. Wilson & Co., of Liverpool] may be used if it is soft mud, sand or silt, and the material may be delivered by pipes to a considerable distance over the banks on either side. One form of dredger found very useful in keeping docks clear of mud consists of an air compressor, placed on board a tug, to blow air through a trailing pipe and stir up the mud at the bottom, so that it will float out with the tide. Bucket dredgers [as 6, by Lobnitz & Co., of Renfrew] are used when the material is more solid; and when it consists of rock, the rock may be broken up by dropping a heavy piece of metal, shod with hardened steel points, on the Lobnitz system.



11. WOOD ROCK DRILL

In the Thames, steam tugs sometimes have a giant rake dropped from the stern, which they drag through the mud that accumulates in front of jetties where ships are berthed, so that it may be carried away by the tide. This is very cheap, but not so effective as the pneumatic dredger described above.

Diving Bells and Dresses. For laying masonry blocks under water diving bells were formerly in use, but these have now practically disappeared, as diving dresses permit of so much more freedom of action. The diver dresses in flannel for warmth, and then puts on the waterproof dress, in one piece from the feet upward. Leaden soles to the feet keep him vertical when in the water, and leaden weights suspended by cords are placed over his shoulders, to hang back and front, as sinkers, to overcome the buoyancy of the inflated dress. The hands remain uncovered, and indiarubber wristbands prevent the admission of water there. The opening at the neck is surmounted by a helmet, screwed on, having thick glass windows through which to see. An air pipe is provided from an air compressor to supply fresh air, the expired air escaping through valves, and a life line is attached to his body by which signals may be made to the surface.

In harbour construction, this method of reaching the work under water is indispensable, and it is also necessary in clearing obstructions from the roller path of dock gates, clearing the windbore, or snore pipe, or perforated suction end, at the foot of a suction pipe in a dock, and for other practical purposes.

The air compressor used consists of a portable pumping apparatus worked by hand, which has to be kept in constant motion so long as the diver is encased in his dress.

Characteristics of Prose. Periods of English Literature and Language. Alfred and Chaucer. The Arthurian Legends.

THE BEGINNING OF ENGLISH PROSE

THE student confronted for the first time with even an elementary work on English prose may well ask himself why he should study it. What *is* the use, for example, of an anthology of English prose? Is it compiled in order that the reader of it may be enabled to form some idea of the origin and development of the language at various periods of its history? Yes, and no. Philological considerations alone do not enter into such a work. There is as much fascination attached to the study of the growth of a language as in the pageant of history. But this is not all.

"It is," as Professor Churton Collins says, "the privilege of Art and Letters to bring us into contact with the aristocrats of our race. It is the misfortune of philology that, in its lower walks at least, it necessitates familiarity with a class of writers who probably rank lowest in the scale of human intelligence." We study classic prose, in short, not only for the light it sheds upon the time in which it was written; not merely because of its intrinsic value as a means of knowledge, but also because of its style. And for yet another reason—which some would place above all the rest—because behind the style is a living man. Herein, for the true student of literature, is the secret charm of our standard literature, and especially of our standard prose. We know, sooner or later, that the noble eloquence, the rhythm, the colour, the tone, the deft management of the period, are all modelled by the great masters of English prose upon the works of the great men who wrote in Greece and Rome when the world was young. But is that a cause for the withholding of our tribute of grateful admiration? Surely what is allowed to the plastic artist, the painter, the sculptor, the architect, cannot be denied the artist in words.

When we approach a work of living prose we may be certain that behind it is a great man, and something more, something of the character of the best of that man's contemporaries, of the spirit of the age in which he lived. It has been well said that genius is the same in all ages, and that writers in the rudest times, as well as those in a more polished and enlightened era, have reached those limits beyond which the faculties of the human mind seem unable to penetrate.

Verse has been, certainly in English, far ahead of prose in the matter of settled law. Hence, as Sir Henry Craik has aptly indicated, we can imitate the rhythm of Spenser without seeming old-fashioned. No cadence in modern verse is more pure, more perfect, than that of Shakespeare's sonnets and lyrics; scarcely any later blank verse approaches the supreme art of Milton. But the prose of the masters and makers of it is even more personal.

As Newman has well expressed it, "while the many use language as they find it, the man of genius uses it indeed, but subjects it withal to his own purposes, and moulds it according to his own peculiarities. The throng and succession of ideas, thoughts, feelings, imaginations, aspirations, which pass within him; the abstractions, the juxtapositions, the comparisons, the discriminations, the conceptions, which are so original in him; his views of external things, his judgments upon life, manners, and history; the exercises of his wit, of his humour, of his depth, of his sagacity—all these innumerable and incessant creations, the very pulsation and throbbing of his intellect, does he image forth.

To all does he give utterance in a corresponding language which is as multiform as this inward mental action itself and analogous to it, the faithful expression of his intense personality, attending on his own inward world of thought as its very shadow; so that we might as well say that one man's shadow is another's as that the style of a really gifted mind can belong to any but himself. It follows him about as a shadow. His thought and feeling are personal, and so his language is personal."

We can only indicate where the student must look for the leading examples of English prose, and point out, as briefly as may be, the chief stages of our prose development. We shall not attempt a disquisition

on Anglo-Saxon literature. That is a very special branch of learning, in which there are few experts. In dealing with English prose, as in treating of English poetry, our object is to keep in view the needs of that large class of the community who should look to literature primarily as a means of education and the source of a pleasure which is not to be confounded with mere amusement.

Early Writers of Prose. The chief characteristic of Anglo-Saxon prose reflects what is a chief characteristic of the English character: practicality. The language was direct and simple. Another point to be borne in mind is that right up to and including the sixteenth century, our prose-writers, beginning with BÆDA (b. 673; d. 735), were in the main translators. Their works were for the most part educational, religious, and historical (as is the "Anglo-Saxon Chronicle") in character. ALFRED THE GREAT (b. 849; d. 901) was a translator himself and the cause of translation in others.

The English that Alfred Wrote. Alfred sought to give his people peace, and he laboured manfully to effect their intellectual improvement. He desired that at least every free-born youth who possessed the means should "abide at his book till he could well understand English writing." He sought to spread wide the learning which was then the monopoly of the clergy. Ballads and poems England already possessed. Prose she had none. He aimed at the rendering of all useful books "into the language which we all understand." This language has been described as one of the finest and purest forms of Teutonic speech. Into it Alfred translated, or, rather paraphrased, in an epitomised form, the "universal history" of Orosius, a Spanish author of the fifth century; the "Historia Ecclesiastica" of the Northumbrian monk Bæda; the "Pastoral Rule" of Pope Gregory; and the "De consolatione philosophiæ" ("On the consolation afforded by philosophy") of Boethius, a Roman philosopher and martyr of the sixth century. Anglo-Saxon was distinct from modern English in the character of its lettering as well as in other ways, but some idea of "the English that Alfred wrote" may be gleaned from the following example, which is given with modernised lettering, from the "De consolatione":

"Hit gelamp gio, thætte an hearpere wæs on thære theode the Thracia hatte. Thæs nama wæs Orpheus. He hæfde an swithe ænlic wif; sio wæs haten Eurydice."

Mr. Cardale thus renders this passage:

"It happened formerly that there was a harper in the country called Thrace. His name was Orpheus. He had an excellent wife called Eurydice."

The work from which these lines are quoted was also translated by Chaucer. Its theme is the mutability of all earthly things save virtue; it belongs to that rare order of immortal works that have been written in prison.

The English of Chaucer. The development of Anglo-Saxon was brought to an end by the Danish and Norman conquests. Some authorities object entirely to the term Anglo-Saxon as descriptive of the language and literature of England before the Norman conquest and for a century after that epochal event, preferring to classify the period as Oldest English, or Old English; but we may follow the conventional classification, which makes Early English succeed Anglo-Saxon and cover the years 1150-1350, as during the first of these two centuries the inflections were broken up, and in the second the language was extended by the introduction of numerous French words [see LITERATURE. page 331]. Middle English, of which Chaucer was the great literary artificer, flourished from 1350 to 1550, and since the latter date our language and literature are classed as Modern English [see page 336]. As was the case with the Anglo-Saxon and Early English writers, their successors of the fourteenth century concerned themselves chiefly with the work of translation. We have already learned that several of Chaucer's works are of this nature—two of the famous "Canterbury Tales": "The Tale of Melibeus," borrowed from the French of Albertano of Brescia, and "The Persones (Parson's) Tale," a sermon derived from Frère Lorens; the unfinished "Treatise on the Astrolabe"; and his "Boethius." Let us look at a few passages from the last named. It will serve to indicate how the language had grown since the time of Alfred the Great.

"At the laste the lord and juge of sowles was moeved to misericordes [mercy] and cryde, 'we ben overcomen,' quod he; 'give we to Orpheus his wyf to bere him companye; he hath wel y-bought by his song and his ditee; but we wol putte a lawe in this, and covenaunt in the yifte: *that is to seyn*, that, til he be out of helle, yif he loke behinde him, that his wyf shal comen ayein unto us.'"

Resistance of English to Norman-French. Though the Norman conquest introduced Norman-French as the language of the court and the cultured classes, while Latin remained the language of the clergy and that in which many learned works were written, the native dialects merged into one another, and ultimately into the Midland tongue. That the French influence was by no means a negligible quantity is evident, if we examine the work of Chaucer alone; but the native English as successfully resisted the Norman-French invasion as our native drama in the sixteenth century rose superior to the dictates of the "University scribes," who sought to shackle it with the dead weight of classical tradition. Following upon the death of Chaucer, however, the French wars and the Wars of the Roses once more set back the clock of English literary activity, and there is but little of interest to chronicle, save the introduction of the printing press by WILLIAM CAXTON (b. 1422?; d. 1491), till we reach the age of the Tudors, whence may be dated the beginning of Modern English.

The Arthurian Legends. One example of the manner in which the English appropriated French literature is to be found in the anonymous translation of "The Voyage and Travels of Sir John Maundeville" of Jehan de Bourgogne, a work which is still read on account of its naïve descriptions of the marvellous. But especially interesting is it to ponder the influence of the romantic legends of the Norman poets known as the Trouvères. These deal with Alexander the Great, King Arthur and the Knights of the Round Table, Charlemagne, and the Crusaders. The origin of the Arthurian legends is Celtic—partly Welsh and partly Breton. "La Mort d'Arthure" of Sir THOMAS MALORY (fl. 1470) so delighted the heart of Sir Walter Scott that he described it as being indisputably the best prose romance of which the English language can boast. Many modern writers, Tennyson among them, are the eternal debtors of Malory, whose work, as printed with all the affection of a great and sympathetic craftsman by WILLIAM CAXTON, played no small part in the making of Elizabethan prose. For his black-letter folio of this work, of which only two copies are known to exist, though a number of reprints are obtainable, Caxton wrote a preface, in which he said, in language that indicates the rapidity of the change from Chaucer's:

Specimen of Caxton's Prose. "I have after the symple connyng that God hath sente to me, under the favour and correctyon of al noble lordes and gentylmen, enprysed to enprynte a book of the noble hystoryes of the said kynge Arthur, and of certeyn of his knyghtes, after a copye unto me delyvered, whyche copye syr Thomas Malorye dyd take oute of certeyn bookes of Frensshe and reduced it into Englysshe. And I, accordyng to my copye, have doon sette it in enprynte, to the entente that noblemen may see and lerne the noble acts of chyvalrye, the jentyl and vertuous dedes, that somme knyghtes used in tho dayes, by whyche they came to honour, and how they that were vycious were punysshed, and often put to shame and rebuke, humbly bysechyng al noble lordes and ladyes, wyth al other estates, of what estate or degree they been of, that shal see and rede in this sayd book and werke, that they take the good and honest actes in their remembrance, and to folowe the same."

Malory's "La Mort d'Arthure." A favourite passage is Malory's account of the passing of Arthur. How English it is, apart from the spelling, may be seen from the following modernised extract:

"And when they were at the water-side, even fast by the bank hoved a little barge with many fair ladies in it, and among them all was a Queen, and they all had black hoods, and they all wept and shrieked when they saw King Arthur. 'Now put me into the barge,' said the king; and so they did softly. And there received him three Queens, and in one of their laps King Arthur laid his head, and then that Queen said, 'Ah, dear brother! why have ye tarried so long from me? Alas, this wound on your head hath caught overmuch cold.' . . . . Then Sir Bedivere cried, 'Ah, my lord Arthur what shall become of me now ye go from me, and leave me here alone among mine enemies?' 'Comfort thyself,' said the King, 'and do as well as thou mayst; for in me is no trust to trust in. For I will go into the Vale of Avillon, to heal me of my grievous wound. And if thou hear never more of me, pray for my soul.'"

Froissart. Malory's monumental work, following that of Chaucer and Gower, gave to English literature something of the glamour of chivalry and romance; and this beneficent influence was followed in its turn by the translation of Froissart's "Chronicles" by LORD BERNERS (or BOURCHIER) (b. 1467; d. 1533). Jean Froissart, like one of his own heroes, set out on his travels in quest of adventure. He visited England twice, in the reign of Edward III. and Richard II.; he was the guest of David Bruce in Scotland, he journeyed in Aquitaine with the Black Prince, and was in Italy, possibly with Chaucer and Petrarch. Ten years before his death he settled in Flanders. His "Chronicles," drawn from his travels and experiences, are among the most delightful things in European literature. Those who cannot read them in French, and are not in love with the spelling of Lord Berners' translation, should have recourse to the Globe edition, which gives a modernised version by Mr. G. C. Macaulay.

The Paston Letters. The student of fifteenth century England should not omit to pay some attention to the "Paston Letters" (1422-1509). These documents, which are about 1,000 in number and were not printed till the second half of the eighteenth century, were written during the reigns of Henry V., Edward IV., Richard III., and Henry VII., by members of an East Anglian family. They throw a flood of light on the social customs of fifteenth century England; and they serve to indicate that the civil strife which then divided families did not altogether crush out either the desire for, or the means of, learning.

The Author of "Utopia." Sir THOMAS MORE (b. 1480; d. 1535) was a man whose thoughts were far in advance of his time. His theories were essentially those of a humane man and a philosopher; his practice, as Chancellor of Henry VIII., was curiously at variance with his avowed sympathies. He was beheaded for refusing to acknowledge any other head of the Church than the Pope. His best known work, the "Utopia," a political satire, was written in Latin, and translated into English by Ralph Robynson thirty-five years later. It deals with the social defects of English life, and pictures an imaginary island where communism is the rule, education common to the sexes, and religious toleration general. The title is derived from two Greek words meaning "Nowhere." More also wrote a number of works in English, of which the most notable is his "Historie of Edward the Fifth and Richard the Third." This is the first history in the language with any pretension to a literary character.

J. A. HAMMERTON

Officers in Public Libraries, Washhouses, Parks, and Gardens. Lighthouse Keepers. Tramway Employees. Hall Keepers. Boys.

LIBRARIANS & EXECUTIVE OFFICERS

In addition to Poor Law appointments, which are reserved for special consideration, there remain several of the Municipal Service departments that may conveniently be included within the scope of a single article. Of these the most notable are the public libraries, parks and gardens, the municipal tramways, and the lighthouse service of Trinity House.

Public Libraries. There are approximately 550 public libraries in the British Isles, employing as many librarians, and some 3000 assistants, of whom 1000 are women. The most diverse views prevail among borough councils as to the remuneration of library officials. Fairly valuable appointments are sometimes made in this service; but, on the whole, it cannot be said to be liberally rewarded. A municipal librarian who is perhaps the most eminent member of the service expresses his opinion on this question with the utmost force. "I should think there is no doubt whatever," he writes, "that, as a class, librarians are not adequately remunerated. It is indeed a simple truth to say that librarians, as a body, are among the worst remunerated officials in the service of municipalities. This is due very largely to the limitation of the library rate." On the one hand, the Guildhall librarian receives £600 a year, the chief librarian of Manchester £550, and his colleague at St. Pancras £350, rising to £500. On the other hand, £80 a year has been offered for an "experienced and qualified" librarian; and in another instance applications were invited from trained officials between 28 and 45 years of age for a head position at £100 a year, without residence.

Such instances are not altogether exceptional. The explanation is twofold: a local authority cannot pay adequate salaries out of an income which is limited by the Libraries Act to a penny rate; and, in the subordinate grades at least, the libraries service calls for few special qualifications. Fair abilities and education, a gentlemanly address, and some previous experience—these comprise the usual requirements for minor positions; and the competition among young men thus equipped is so great that salaries rule low. In recent years, however, organised and partly successful efforts have been made to raise the status and improve the position of municipal librarians generally.

Salaries in the Various Grades. The service is chiefly recruited by youths entering either as evening assistants at a few shillings weekly, or, more generally, on a full-time footing as junior assistants at £25 or £30 a year, rising to perhaps double their initial salary. Most local authorities now require candidates either to pass a preliminary examination, or to hold such a certificate as the Oxford or Cambridge Senior Local. On promotion to senior grades the earnings of assistants, starting at £70 or £80 a year, will reach £100, £120, or £150, the last figure being seldom exceeded for auxiliary posts. The next step—either a branch librarianship or a small independent command—may mean but a slight advance in salary, the average range for such an appointment being from £120 to £180 a year, with or without rooms. Its importance to the young official lies in the chance thus afforded him of proving his judgment, organising skill, and general fitness for the responsibility of a principal position.

Leading appointments, as already indicated, are very variously repaid. In the borough of Wandsworth, possessing six important public libraries, one librarian receives £350 a year, with residence, light, and fire; and three other officers in charge, £250, £230, and £150 respectively, with similar emoluments. Lambeth pays its chief librarian £250, with residence. These figures represent, probably, the average value of such posts, though salaries of £450 and upward are paid to chief librarians in some large towns.

Ladies as Librarians. The libraries service affords a field of fairly well-paid employment for women, many of whom are engaged by local authorities in subordinate positions and as branch librarians. Few women hold chief positions. The rate of remuneration for lady librarians is generally less than for their masculine colleagues, junior assistants receiving from £20 to £40 yearly, and seniors £50 to £80 or £100. Manchester has placed four of its branch libraries in charge of ladies, with salaries ranging from £80 to £120 a year; and in the libraries of several London boroughs a small female staff is employed at similar rates.

The Training of Librarians. A prominent municipal librarian has kindly communicated the following valuable summary of the methods of training available to assistants who desire to improve their standing. "The training for librarianship is given in the individual library, but is systemised by the Library Association, of Caxton Hall, Westminster, S.W. This is an incorporated body devoted to the propagation of libraries, the perfecting of their methods of administration, and also to the training and examination of librarians. Under the auspices of this association, lectures are given at the London School of Economics, and in various provincial centres, such as Birmingham, Manchester, Liverpool, and elsewhere. The syllabus of the association consists of the six subjects: literary history, bibliography, classification, cataloguing, library history and organisation, and library routine, for each of which professional

certificates can be obtained. The complete diploma, carrying fellowship of the Library Association (F.L.A.), is issued when the candidate has all six certificates and gives evidence of certain other qualifications. Few men as yet have the full diploma; but the professional certificates are held by hundreds of students, and are required of candidates by library authorities, as a rule, for all senior appointments."

The Library Assistants' Association. This body, which is not to be confounded with the last, is formed exclusively of persons professionally employed in libraries, its object being to promote their educational and general interests. It has done much useful work in drawing public attention to the needs of assistant librarians and in improving their professional status. The honorary secretary is Mr. W. C. Berwick Sayers, Central Library, Town Hall, Croydon.

Baths and Washhouses. During recent years, many local authorities have realised the urgent need for promoting cleanliness—both personal and domestic—in their districts. One result of this awakening is manifest in the numerous and well-appointed public baths and washhouses owned by municipal bodies in every part of the country. These buildings—some of which contain elaborate and costly apparatus for vapour, electric, and medical baths—are generally placed in charge of a superintendent, with or without the aid of a matron.

The position of baths superintendent is a responsible one, requiring a sound practical knowledge of hydraulic and heating apparatus, as well as good organising powers. A typical advertisement of such a vacancy stated that "Candidates must be thoroughly competent to take charge of the building and machinery, and those whose qualifications include a knowledge of engineering will receive special consideration." In this, as in many other instances, it was stipulated that applicants must be not more than forty years of age. The value of these posts may be best shown by a few examples. In addition to residence, light, and fuel, the superintendent of baths for Manchester receives £350 a year: at Westminster, £250 (advancing to £300); and at Battersea, £200. The superintendent and matron of the Wandsworth baths are paid a joint salary of £200, with the usual allowances. Corporations owning several public baths often place an expert *masseur* and bath attendant in charge of each as manager, under the general control of the superintendent, at a stipend of £120 or £150 a year. For attendants and shampooers, the customary rate of pay in municipal baths is 30s. to 40s. a week.

Parks and Gardens. The foremost municipal owner of open spaces is probably the London County Council. That authority can boast of 108 pleasure grounds, covering 4960 acres, for the care of which a permanent staff of 900 men is employed. Efficiency is encouraged in the L.C.C. service by filling all the higher posts by promotion. Applicants are admitted either as gardeners at 28s. a week, or as labourers or under-keepers at 27s. From their ranks selections are made for the respective superior grades of propagators, foremen, and headkeepers, and so up to the highest position attainable—that of park superintendent, at a maximum salary of £225 a year, with a house, gas, and water free. Candidates, who must be between 25 and 40 years of age, may obtain application forms and further particulars from the Parks Department, 11, Regent Street, London, S.W. For gardeners, the Royal Horticultural Society's certificate in practical horticulture is a very useful recommendation.

Save that in provincial areas the average of salaries is somewhat lower than in London, this example will serve to illustrate the general conditions of service in municipal gardens and cemeteries throughout the country.

It may be mentioned, however, that the post of general superintendent of parks (worth in the larger boroughs from £250 to £450 a year) is usually to be reached by direct promotion, which is not the case in London; and that a clerical registrar is appointed to each cemetery, at a salary averaging £250 a year.

The Coastwise Lights. The lighthouse service of England and Wales is under the jurisdiction of that quaint and ancient "Corporation of the Trinity House at Deptford Strond," which now has its headquarters on Tower Hill. The Trinity House is a foundation of unknown antiquity, that was already a flourishing institution when the eighth Harry granted it, in 1514, its earliest Royal charter. In addition to controlling the lighthouses and lightships of the coast, the Corporation is entrusted with the management of the general buoyage system, and the removal of dangerous wrecks around our shore. For the execution of these duties, a large staff of men is employed in the lighthouses, lightships, and steam-vessels of the Corporation. The strength of each branch is approximately as follows: Lighthouse keepers, 200 to 250; light-vessels staff, 550; and steam-vessels, 180 men, excluding officers. The conditions of entry into this service, and the rates of pay obtaining in it, are as under.

Lighthouse Keepers. Candidates must be between the ages of 19 and 28, and unmarried. They are required to produce certificates of birth, health, character, and education—the last requirement comprising reading, writing from dictation, and a fair knowledge of arithmetic. In the selection of men for employment, preference is given to artisans and sailors. On entering the service they are classed as supernumeraries, are supplied with uniform, and are paid 2s. 6d. a day. When qualified for appointment to a lighthouse as assistant keepers they receive 3s. a day, with dwellings, coal, and light (or a money allowance in lieu thereof), and are entitled to medical attendance at a nominal charge. Their daily pay increases by gradual increments to 4s. 6d., the maximum pay of a principal keeper. By a wise provision the life of every keeper is insured by the Trinity House for the benefit of those who may be dependent on him. For this purpose the Corporation pays

a fixed annual premium of £3, the value of the policy depending on the officer's age on entering.

For the light-vessel and steam-vessel branches, applicants must be seamen under the age of 32, and must provide certificates of birth, character, and sea service in the A.B. class. A member of the crew of a lightship receives 4s. 4d. a day on entry, rising through various grades to 6s. 4d., the maximum pay of a master. On the steam-vessels the rate of pay for seamen is 4s. 7d. a day, and that of other ratings lies between 4s. 7d. and 5s. 11d., the maximum wage of carpenters. Officers in the steam-vessel branch are appointed from those who have been apprenticed to the service as youths. Vacancies for such apprentices are not frequent. In either branch the seaman's uniform is furnished free, but every man has to provide his own food. After three years' service each man is insured.

Men in the lightship service are afloat for two months at a spell, and are then allowed a month ashore. During the shore turn, however, they must report themselves for duty at the district depot, and are occasionally required to form part of the crew of the district steamer, in which case they receive extra pay. Masters and mates of light-vessels spend alternate months afloat and ashore. Officers of the Trinity House are granted pensions at the usual Civil Service rates.

The Tramways Service. There are some 82 municipal electric tramways in Great Britain, conveying every year more than 2,300,000,000 passengers. Employment is thus afforded to a huge industrial army, on terms which are generally more liberal—in respect alike of higher wages and shorter hours—than those exacted by private companies. The Tramways Department of the London County Council numbers 10,000 workers, from general manager to car washer. Apart from administrative officers, its employees are remunerated at the following typical rates: Motormen and conductors, 5s. a day on entry; after six months, and on passing the first-grade examination, 5s. 3d.; 5s. 9d. after a further six months; and at the end of another half-year, 6s. 3d. a day. This is the maximum for conductors; but motormen proceed to 6s. 6d. a day on passing a further examination. An overcoat, uniform coat, and two caps are allowed yearly. Foremen earn £2 to £3 10s. a week; regulators, £2 2s. to £2 4s.; electrical mechanics, £1 11s. 6d. to £2 0s. 6d. There are also a number of car-washers and track-cleaners, earning between £1 and £1 10s. a week; as well as carmen, permanent-way men, and labourers, at standard rates of pay.

Vacancies in the municipal yards are usually filled by the Chief Officer of Tramways. In the case of the L.C.C., applications for employment should be addressed to that official at 303, Camberwell New-road, S.E.

Hall-keepers. The London County Council pays its hall-keeper and his wife a joint salary of £280 a year, and its assistant hall-keeper £153; but these rates are unusually high. According to the nature of the duties exacted, the remuneration of the town-hall keeper generally varies between 30s. a week and double that sum—always with residence, coals, light, and uniform. Yet, modest as it is in position and in official rewards, a vacancy of this class is eagerly contested, for a hall-keeper's extra earnings often equal his salary, and are sometimes far in excess of it.

Beyond fixing an upper age-limit of 45 or 50, and stipulating sometimes for the absence of "encumbrances," the qualifications of hall-keepers are rarely prescribed. Those which commend themselves most to the appointing authorities are good organising powers, smartness and method, previous experience, regularity of habits, and some education.

School-keepers are paid from £1 to £3 a week, according to the size of the buildings under their charge. Ex-soldiers and men who have served in the Navy are often selected for this work.

Messengers, Caretakers, and Others. Municipal messengers, caretakers, and porters, as they differ in no wise from their colleagues outside the public service, need occupy but very few words. They are generally appointed from "waiting lists" kept by the council's clerk. Applicants possessing such modest qualifications as these posts require should, therefore, secure the addition of their names to the queue of "suitable persons." This list, however, is usually a long one, for the public service, like all others, is most crowded at the foot.

Boys Under the L.C.C. "Blind alley" occupations for the young, affording no training for adult employment, constitute an evil which that model employer, the London County Council, has made strenuous efforts to avoid. The Council employs a number of lads who cannot be retained at their posts after the age of 18, but every inducement is given them to qualify meantime for permanent work on its adult staff. Free educational and technical classes and trade schools are provided, and every boy employee is required to attend them regularly, and is allowed six hours' free time weekly for the purpose. Boys who do creditably in their employment and at the classes are recommended by their superiors for the Council's "Register of lads suitable for adult employment"; and whenever a permanent post becomes vacant, the names in this register are specially considered.

These vacancies are of various grades. Apart from mechanics and artisans of all kinds, there is a large staff of messengers and attendants at rates varying between 18s. and £2 a week. But lads who have profited by their instruction have higher possibilities elsewhere. The Council's tramways department, and that of its chief engineer, have well-paid posts for skilled workers; there are openings for trained gardeners in the parks, for upholsterers and packers in the stores branch, and for men clerks on the general establishment. With such opportunities and encouragement, the lad who fails to get adult employment under the Council by the time he is 18 has not utilised his chances.

ERNEST A. CARR

The Advance of Vegetable and Animal Life Compared. The Consciousness that Makes for True Progress in Animal Life.

THE ONWARD MARCH OF LIFE

Considering simply the visible facts before us, we completed in the last chapter our first survey of the living world, with its manifest division into two kingdoms, animal and vegetable, and the not unparallel series and stages, from lower to higher, which each exhibits, culminating, hitherto, in the noblest trees at the head of the flowering plants, or phanerogams, and in man, "the paragon of animals," at the head of the mammalia. It is a varied yet not disorderly spectacle, this bird's-eye view of the living world; we see a suggestion of a plan, or what looks like a plan. Yet more; it is a grand spectacle, in its scale of magnitude and its scale of time, but above all in what has been *achieved.*

The New Ideas and the Old. We are contemplating the stages and the accomplishments of a *process.* We are looking at history. In the living world the past is present before our eyes, and the present is pregnant with the future.

These ideas may or may not seem self-evident to the reader, but they are entirely ideas peculiar to our own day. A century ago, a mere three generations, when the world was just as wise in most things as today, when Goethe was thinking, and Kant was but lately dead, such ideas as those of the last paragraph were all but unheard of, and, if heard of, were received as outrageous, scandalous, blasphemous. We, today, are "thinking in evolution;" we breathe ideas of evolution in the atmosphere of our time, and they seem inevitable, as verily they are to the awakened mind.

Seeking an Explanation of Life. Our task now is to attempt a deeper survey than our first, which was only superficial, in the proper sense, dealing only with visible forms and material sequences. For if those forms, in their likeness and unlikeness, their long and unfailing succession, are a *process,* the real heart of our problem is to define that process. If these various forms are merely the outward and visible signs of an inward and invisible process, the true science of life must see through and beyond the signs to that which they signify.

When the older ideas had not yet been proved to be false, an explanation of the real meaning and origin of living things was required, and the answer was that they had been specially created by God in the forms in which we now find them. But now that science has infinitely enlarged our ideas of Deity, and has demonstrated the fact of evolution, we must find a new meaning in the phenomena before us.

What Makes Things Change? What is going on? What gives origin to the new things that appear in the history of life—bones, intelligence, leaves, wings, love, "Hamlet," London, the Society for the Prevention of Cruelty to Animals, and so on and so on, *literally* ad infinitum? Some will answer evolution, as if that were an explanation. It is nothing of the sort. The wisest men in the nineteenth century knew it was not. Lord Morley, long decades ago, pointed out that evolution was a law and not a cause—a mode in which action occurred, but not a statement of the origin of that action.

The rationalists and materialists and anti-theologians in the nineteenth century believed and asserted that in the word "evolution" a real explanation of things was contained. Herbert Spencer, the mighty master whom they could not understand, and who introduced the word "evolution," never made this monstrous mistake. He devoted his life to proving that evolution is the mode, the method, the way of the universe; and by evolution he meant, as we have elsewhere stated, universal and ordered *change*—nothing more and nothing less. Spencer and the other pioneers did absolutely demonstrate beyond all cavil, and every succeeding year demonstrates afresh, that this ordered change, or evolution, is the fact. But what was not forthcoming was the *explanation* of what Spencer and the rest *described.* What makes things change, what brings new things to the birth, and how? These are the great questions which remain for our century, and perhaps for many to come.

Progress in Nature Defined. Our subject here is Life and Mind, and the very title implies a profound relation between the two. Remembering this proposition, let us look again at the animal and vegetable kingdoms, with our eyes directed to something deeper than structure or external form. We shall see a profound distinction, which has now become even more significant in the light of Professor Bergson's thought. In both animal and vegetable kingdoms we see an immense advance in structure. The oak is perhaps as far above the alga in structure as man is above the amœba. There has been a mechanical or structural evolution in both kingdoms. In general speech, there has been *progress* in both kingdoms. But is it wise to use the word "progress" in this sense? We believe that it is not. Progress, we maintain, should be defined as the *revelation and increasing dominance of Mind.* Whatever may have sufficed for the pioneer evolutionists, who had a hard enough task in demonstrating the fact of evolution against superstition and entrenched prejudice, we today must not be content with the repetition of their assertions on that easy level. We must look deeper, as they would now be doing if they were still alive. We must distinguish between evolution in general and the

particular, priceless, divine form or result of evolution which we shall call progress. It was just because people confounded the two things that Herbert Spencer introduced the non-moral, strictly neutral term "evolution"—*a rolling and unfolding*—as a substitute for the term "progress," which, alas! is applicable to only a part of the evolutionary process. Degeneration, decadence, atrophy, loss of what has been gained—these are just as possible and just as frequent in the course of evolution as is real progress. Never, never must we confound the meaning of the two terms or the two ideas.

Mind Essential to Progress. Now, if progress (or *progressive* evolution) be the revelation and increasing dominance of mind, look at the animal and vegetable kingdoms, and compare them. At once we see the tremendous fact that there is, indeed, no real comparison between animals and plants in this respect. The pioneers of natural history, in Greece or even farther East, saw what we all see and regarded vegetable life as not really life at all. In so doing they unconsciously expressed the idea that Life is really Mind. Where they saw something that mimicked life, but yet displayed, or seemed to display, no mind, they felt compelled to deny that this could really be life at all. And today we feel, in something deeper than our explicit reason, that in some real sense a cabbage is far less alive than a rabbit. To a sleepy or slow-moving companion we say "Look alive," meaning that unless there be *signs of mind* we cannot admit his title to life at all.

Now, the tremendous truth which is to be added, in this age when the fact of evolution is granted, is that the animal and vegetable kingdoms display the most extraordinary historical contrast when thus surveyed. Progress, as we have here defined it, belongs almost exclusively to the animal kingdom, though structural evolution has been achieved in and by both. The ancient Indian saying is that "God sleeps in the vegetable, dreams in the animal, wakes in man." That sublimely expressed distinction is a thousand-fold more significant today, when we know that vegetable, animal, and man were not created by God as they now are, but are the results of an evolutionary process. That process must be compared to a kind of stream or current, with force behind it, which has taken *at least* two directions—really three, as we shall see—and it is only along the second of these that we can recognise progress, properly defined.

Vegetable Life Unprogressive. The fact is that vegetable life, though real life, does not display progress at all, or, if at all, only in trivial degree. It has achieved and does achieve wonders in the physical and chemical sense, but it does not constitute the revelation and increasing dominance of mind. So to say, there is no more intensity of mind in the oak than in the alga. If mind could be measured quantitatively, as it cannot, we might say that there was a greater quantity, a greater extension, of it in the oak, because the oak is bigger. But, of course, that means nothing more than that where there is more living matter there may be more mind displayed. The oak does not *reveal* mind more than humbler forms of vegetable life, nor can we say that in the oak the mind factor is more dominant over the material than in the alga.

It is not here asserted, nay, it is denied, that the vegetable kingdom has no mind in it. Far from that. The most recent experiments of botanists, such as Sir Francis Darwin in this country, to name only one of many, are showing that what can only be conceived as mind does exhibit itself in the vegetable world. We may go further, and even admit that, to some slight extent, and in degree which is still disputed, the higher plants show certain sensory, which are really psychical, powers, in more varied and capable form than their humbler ancestors. It may well be so. As Bergson has argued, each of the directions along which life has flowed may still show us something of the original capacity and potentiality of living beings, so that, for instance, we may find vegetable qualities in ourselves, and even such qualities as something like instinct, if not intelligence, in plants. Therefore we must not make our assertions and distinctions too absolute, for that would be to miss one of the most important lessons that Bergson has taught us. But, with that qualification, and not forgetting the recent evidence of something like elementary vision in leaves, we may say that the vegetable world does not exhibit true progress.

Anatomical Comparison of Plant and Animal. Looking at the visible or structural aspect of living forms, we can re-state this proposition. We have already seen that the essential difference between the one-celled and the many-celled forms of living creature is not that the latter are many-celled, but that they are different-celled. Indeed, we might go so far as to say that the number and extent of the differences exhibited between the cells composing any organism furnish a true index to its place in the evolutionary scale. Look now at the oak and compare it with, say, the dog. At once we see, when the razor or microtome and the microscope have been employed, that the oak does not exhibit anything like such cell-differentiation as any high animal with which we may fairly compare it, such as the dog. Anatomically, all plants, even the highest, are simple compared with the higher animals. Of course, they show cell-differentiation, and also the organising of different kinds of cells, or of combinations of different kinds of cells, into tissues and organs. But if we were to catalogue the cells in an oak, as could easily be done, and then similarly to catalogue the cells in a dog, as might, with vast pains and time, be also done, we should find that the one form of life involved not a hundredth part of the cell-differentiation which is required in the other.

But even the question of the numbers of kinds of cells does not cover the whole structural difference between vegetable and animal. We

must proceed to compare the two, and tick off, so to say, in the two catalogues, those which correspond with each other, performing identical or analogous functions, and which thus, as it were, cancel each other. At once we find that the external protective cells of the bark of the tree, for instance, correspond to the external cells of the skin of the animal; and each may produce what are only to be called hairs in both cases, though their actual structure and mode of formation may be very different. Further, oak and dog both exhibit cells for sheer mechanical strength, such as the wood-cells of the tree or the bone-cells of the animal, together with the not-living products of each. Again, in oak and dog we find germ-cells, for reproduction, male and female. In both we find cells or tissues concerned with excretion of waste products, cells or tissues concerned with breathing, cells or tissues or glands concerned with chemical processes—the laboratories of the living being.

What the Vegetable Kingdom Lacks. In due course we shall totally exhaust the whole catalogue of cells and tissues in the tree, having found analogous cells or tissues in the animal. But much will remain in the catalogue of animal cells; and the all-significant fact, upon which all else depends, or which expresses all else, is that in the animal body we find a kind of cell which has no parallel or analogue *at all in any vegetable organism whatever.*

These, of course, are nerve-cells. It is now beyond dispute, though the opposite has been maintained in the past, that no plant contains any nerve-cells, nor, of course, any nerves, which are simply processes or prolongations of nerve-cells. The nervous system of the animal is its own peculiar property and characteristic. Examine the brain of the dog, or, indeed, of many humbler creatures, and much more the brain of man, and there we find almost incredible numbers of cells, to be counted only in millions, which are of an immense and hitherto uncatalogued variety, though all are nerve-cells, and to which the whole vegetable kingdom, taken together, past and present, cannot furnish one solitary parallel.

Thus, on the anatomical, structural, material side, we have discovered the expression of the fact already asserted, that vegetable evolution has not involved progress, which is the revelation and increasing dominance of mind. The organ of the mind is the brain, and there is not, nay, there cannot be, such a thing as a vegetable brain. In the vegetable kingdom life has proceeded, and is proceeding, along what we must not call a *totally* different route, for that would be to forget the fundamental identities of all life, but yet a route so different that no words could well over-emphasise the immense contrast which the higher forms of animal and vegetable life now display.

Vegetable Evolution Uneventful. Thus the history of vegetable evolution is, relatively, tame and uneventful. Not for a moment must we say that it is uninteresting, or that it is of no consequence. That would be peculiarly foolish today, when palæobotany, the study of extinct forms of vegetable life, has made such strides, and when the consequences of the past vegetable life of the earth, in the form of coal, peat, petrol, and so forth, are assuming ever greater and greater practical importance. But if it were our duty here, as it is not, to make a systematic study of vegetable evolution, from the unicellular forms up through mosses and ferns to the flowering plants, we should not find our journey punctuated by tremendous and epoch-making events. There is no moment in the whole record at which we have any thrill, such as the true biologist must feel when he studies animal evolution, and sees for the first time a tiny, easily missed speck of nervous matter of which, prophesying after the event, he can say, "Here is the birth of that which becomes the cerebrum of man, that by which he weighs the stars, moves mountains, and well-nigh commands the winds and the waves, that they do obey him." In other words, as we watch the growth of a plant, or as we recount the evolution of the vegetable kingdom, we do not meet that incomparable, incomprehensible, sublime spectacle which is the commonplace of the animal kingdom—the revelation and increasing dominance of mind, whether briefly in the infant that becomes a man or woman, or at æonian length in the record from the amœba up to the human race.

Progress Dependent on a Developed Nervous System. There is yet another way of expressing the same contrast. The most evident revelation of mind is *consciousness.* Compare plant and animal. Is the oak more conscious than the alga? We must answer no. Wonderful and glorious as has been the structural evolution of the vegetable kingdom, more consciousness has not been the fruit of it. On the other hand, the highest animal is the most conscious, even self-conscious, thinking that "this is I," and "looking before and after," in Hamlet's great phrase. Examine the body and try to name a seat of consciousness. Quickly we reject bone and muscle and gland and pass to nerve-cells, and literally above all, to the nerve-cells of the cerebrum or great brain, of which no plant has any analogue or the remotest foreshadowing. The history of progress, therefore, in the definition of that much-abused term which we ask the reader to accept, is, on the structural side, the history of the invention and evolution of the *animal nervous system.*

Semi-consciousness, wariness, capacity of sensation must be co-extensive with all life. The leaf of many a plant is obviously sensitive, and can be anæsthetised by chloroform exactly as any human being can. Let this be absolutely clear. *But,* while the vegetable kingdom has evolved superbly along other lines, it has not evolved at all in the formation of structures—nerve-cells—through which the consciousness inherent in life becomes intense. As Bergson profoundly says, "The group must not be defined by the possession of certain characters, but by its tendency to emphasise them."

Because all life is one, we cannot define and distinguish plants and animals even, to say nothing of smaller divisions, by saying, for instance, as has been said for centuries, that the animal possesses consciousness and the plant does not. Nor can we any longer say, as has been said for decades, that the plant has the power of building up chemical compounds and the animal has not. In these, as in all other cases, further inquiry shows that the plant has *some* measure of consciousness and the animal has *some* power of chemical synthesis. The definition of each group must therefore depend, as Bergson says, upon its *tendency to emphasise certain characters.* In the animal kingdom, as we have insisted, the tendency is toward increasing wariness, intenser consciousness, and the development of the highest and most mysterious form of matter that exists—the living nerve-cell.

Bergson's View of Evolution. The vegetable tendency is different. It is chemical. Above all, it is the power, so fundamental that we have already discussed it carefully, of fixing the carbon in the carbonic acid of the air in the presence of sunlight. Yet again, experiment has lately shown that, under certain conditions, some animals can do this. We must not be disconcerted, but enlightened, thanks to Bergson. This fact simply shows, again, that life is one, and that we must define by tendencies, and not by fixed states. Our very definitions of life must themselves be evolutionary or dynamic, instead of static, as in the past. And the facts of vegetable functions in animals, and of animal instinct, or even intelligence, humbly displayed in vegetables—these and a countless host besides, notably the evolution of essentially similar reproductive apparatus and methods in both kingdoms—prove the great proposition of Bergson, that the evolution of life has not been *linear*, but along many divergent lines.

Until his time we have constantly thought of the humbler animals as evolving from the plants, and of intelligence in the higher animals evolving from the instinct of the lower ones; life evolving along one single line. But no reader of "Creative Evolution" can fail to realise that this was wrong. There was, so to say, one stream of life, which has divided into two or three or many streams, each partaking in fundamentals of the nature of all the others, yet each distinguished by its *direction*—by its *tendency* to emphasise and exploit certain of the original powers of life rather than the others. How much illumination this new conception sheds over the whole problem of organic evolution only those who have wrestled with it for decades can fully say.

Routes of Animal Evolution. Animal evolution has taken two notable directions, one along or by instinct to the social insects, and one along intelligence to man. The most convenient word for the vegetable world to contrast with instinct and intelligence is torpor. As Bergson says, "The membrane of cellulose, in which the plant protoplasm wraps itself up, not only prevents it from moving, but screens it also, in some measure, from those outer stimuli which act on the sensibility of the animal as irritants and prevent it from going to sleep." The plant is, therefore, *compared with the animal*, unconscious; but we must beware of being misled by such a use of the term. It is only relative. A sleeping child is unconscious, compared with the same child awake; but it is acutely conscious compared with the same child dead. The plant cannot be wakened as the child can, but its unconsciousness is not therefore absolute.

We must learn to think in terms of tendencies. Remembering this principle, and the relative character of our too abrupt terms, we reach and realise the propositions thus reached by our great contemporary master:

"Consciousness and unconsciousness mark the directions in which the two kingdoms have developed, in this sense, that to find the best specimens of consciousness in the animal we must *ascend* to the highest representatives of the series, whereas, to find probable cases of vegetable consciousness, we must *descend* as low as possible in the scale of plants—down to the zoo-spores of the algæ [called zoo-spores because they have such *animal* mobility], for instance, and more generally to those unicellular organisms which may be said to hesitate between the vegetable form and animality. From this standpoint, and in this measure, we should define the animal by sensibility and awakened consciousness, the vegetable by consciousness asleep and by insensibility."

The Vital Difference in Plant and Animal Development. Thus, even when we have closely scrutinised the highest known forms of vegetable life, we can only say that we see in greater extent and efficiency of action the characteristic chemical power which we have already discussed. While the animal kingdom has been revealing mind and intensifying consciousness through the evolution of the nervous system, the vegetable kingdom has simply been increasing and making more efficient its chemical power under the influence of sunlight. Its response to sunlight is its nearest analogue or parallel to the animal's sensibility to all manner of stimuli; and though this animal sensibility includes response to sunlight, it is the plant that responds in the wonderful chemical manner already discussed. Indeed, we must say that the nearest parallel to the nervous system of the animal, and thus the highest product of vegetable evolution, is the physico-chemical apparatus, still mysterious and beyond the power of science to imitate, by which it captures the energy of sunlight and makes it available for itself and animals as the chemical energy of starch and sugar.

In Bergson's words, this amounts to saying that "the plant can have no nervous elements, and that *the same impetus that has led the animal to give itself nerves and nerve-centres must have ended, in the plant, in the chlorophyllian function.*"

C. W. SALEEBY

Eliminating Waste. Controlling the Stores. Speeding Up. Inducements to Workers. Checking Output.

FACTORY ORGANISATION

As already explained, the office is the brain of a business, and any failure there must of necessity make itself felt in the business as a whole. But a well-organised office is not in itself sufficient to ensure success. Something more is needed. The various other departments must also be properly constituted, and in none of them is this so important as in the factory.

If the producing department is not thoroughly organised on a scientific basis, so that the best and the most is obtained from each worker and each machine, then the business as a whole is suffering, and money that might be made is being lost, no matter how large the actual profits may be. Where the margin of profit is not great, slackness or muddling in the factory may mean an absolute loss on the year's trading, with no return at all on the capital that has been invested.

The essence of factory organisation is to eliminate waste of time and material, to work with the least amount of labour consistent with efficiency, and to ensure that the quality of the work produced shall never be below standard, but shall, if possible, improve with increased experience. Of course, a whole volume might easily be written upon factory organisation and management, and still leave the subject unexhausted, but in this chapter it is proposed to lay down the general principles of up-to-date organisation; and the reader who is interested will be able to work out the details for himself to suit the particular kind of business in which he happens to be interested or engaged.

Managerial Qualifications. First of all, let it be said that no man who occupies a position of trust and responsibility in the factory can be too well educated for his work, and this applies also to the ordinary workman who aspires to improve his position and his salary. The old idea was that for the manager of a factory all that was needed was a practical man who thoroughly knew the various processes of manufacture, and that it was at least a matter of indifference whether he had any education outside of his particular craft. Such an idea has long been exploded. It is true the man who is going to manage a factory, or any department in it, must know the various processes that come under his control, but he must be more than a mere glorified mechanic. He must have education and initiative, and tact and courage.

He must have education, or he can never use to the best advantage the practical knowledge which he possesses; he must have initiative, or he will merely allow the work of the factory to proceed on the lines laid down by his predecessor and continued in the same way, perhaps for years. Rather should he make it his business to improve every department and process, and devise better ways of carrying out the details, so as to justify the confidence placed in him by his employers when they made him head of the works, or of a department in the works. These improvements and new methods will be introduced gradually and almost imperceptibly, so as not to upset any of those who have worked under the older system. It is here that the necessity for tact comes in. No man can possibly succeed in a position of authority in the factory who has not the ability to handle men in such a way as to get the best out of them, and this can only be done by leading and not by driving them.

All this, of course, requires courage; and the successful man is never the one who is always trying to push off upon others the responsibilities which he himself should assume, and who is afraid to take risks. "Nothing venture, nothing have," is an old proverb, but it is a true one; and while it is not suggested that a factory manager is to have what can in any sense be described as the gambling spirit, he will never make progress if he is always afraid to strike out into any path that has not previously been taken by others. It is not by such lack of courage that great businesses have been built up or are being built up today.

Thinking Ahead. The man who aspires to hold any position of control in the producing side of a manufacturing business should ever be a learner, for he can never know too much, and it is in the working out of the details that education tells. The really able and gifted man may do much by instinct and intuition, but without education he can never achieve the best. Human knowledge is progressive, and the true business man is always discovering something new that he can turn to account. He must, if he is to keep abreast of the times and be ahead of his competitors, know about the new problems that are constantly arising in economics, and he will plan ahead to meet the requirements of probable new legislation affecting factory life and work. He will study the new developments in engineering, the new discoveries in geography, the new situations in the life and government of the nations, for any or all of these may mean new markets for new lines of manufacture, new methods of producing, and new shipping routes. He who desires to get into the front rank of business men will be a diligent reader of the newspapers, including those trade organs that deal with his own particular business; and not the least valuable columns for regular and systematic study are those devoted to advertisements,

where particulars will be found of new inventions and appliances, and of books dealing with subjects of importance to the factory manager.

On page 1127 is a table showing the principal departments into which a large factory is generally divided. It is difficult to pick out any one of these and describe it as the most important, for if the factory is really well organised all the departments are interdependent and are almost equally important, each having within itself potentialities which may mean profit or loss to the business as a whole. On account of the intimate relations of the different departments, there is in all large factories nowadays a system of intercommunication by telephone, a central exchange somewhere in the building connecting up the different departments as required. The telephone has been of inestimable value to the factory, saving much running about by messengers and much waste of time by the workers, who can be rung up from the manager's office or elsewhere and spoken to without the necessity of going from one part of the building to another to take some trivial instruction. The value of the telephone is the greater the larger the factory premises, and the more considerable the distance of one department from another.

The StoreKeeper's Responsibiltiy. A very important section of the factory is the stores, and the storekeeper is an official with great responsibility, for he is the guardian of all the materials to be used in the manufacture of the finished goods. He receives the various materials as they come in, he is responsible for their safe and suitable storage, he is answerable for them so long as they are in the stores, and he is also responsible for their proper distribution. He must keep correct and complete records of all goods received and on order, of all that have been handed out to different departments, and of all breakages or deteriorations.

These records must account for everything. They should be kept upon the card-index system, as described upon page 1129. Questions of prices and invoices are dealt with in the general office by the stockkeeper, but it is essential that the man actually in charge of the stores, who is responsible for handing out the goods to the different departments, should himself be able to know in a few minutes just how his stock stands. The storekeeper in the factory will, of course, supply the stockkeeper in the office with periodical records of the outgoings, so that the records of both may tally.

How Stores are Kept and Checked. The position of the stores in the factory must be as central as possible, so as to be fairly accessible to all the departments drawing from them; and here, if anywhere, organisation is of supreme importance, or there will be disastrous delays in finding exactly where things are when they are required. The size and character of the stores depend upon the particular kind of business concerned, but, whatever the business, except for the very largest articles, racks and bins are necessary, arranged in rows with convenient corridors or passages between them. Every rack and bin should be numbered, and both storekeeper and stockkeeper must note these numbers on the card records of all goods, so that should the storekeeper or his assistants be away at any time, or should there be a sudden change in the personnel of the staff, there is no difficulty in the new employees knowing where the various articles are to be found. Any neglect of this very necessary precaution may mean at some time endless delay and serious loss of time and money.

The Checking of Goods on Delivery. All goods must be unpacked, if possible, as soon as they arrive, and checked and examined to see if quantities correspond with delivery notes and official orders, and also to see if they are up to standard quality and in good condition. The empty cases or other packages in which they came should be returned as soon as possible. Such matters should not be left to chance, but should be attended to according to a specified routine, and for each operation and class of goods some individual should be made definitely responsible. Records of every transaction, with dates and other necessary particulars, must be kept and duly filed.

The stores of a factory representing such a considerable capital value, it is obvious that there must be a thoroughly efficient control, and that the system of giving out stores must be placed on a scientific basis. In the first place, it goes without saying that nothing whatever will be given out except in exchange for an official requisition form, duly signed by the head of the department to which the stores are going. This requisition form will specify the exact articles and quantities required. The old method of allowing stores to lie about in the different departments, without any proper control or supervision by a head responsible for the stores as a whole, is so wasteful that it is now almost obsolete. It will quickly be recognised that any such haphazard method must result in loss and deterioration, besides which the workmen will come to regard such stores lightly and to look upon them as of little value. This will increase waste ; and where the articles are small, and of use for ordinary domestic purposes, there is the temptation to petty theft.

Taking Goods from the Store. Stores cannot be guarded too jealously or controlled too strictly, and the factory manager must personally see to it that the system in vogue is effective. The storekeeper will have a small corner of the stores partitioned off as an office, and to this office will be brought all official requisition orders. In large factories there is often a pneumatic tube to the storekeeper's office, and the orders are sent through this. All requisitions from the departments should first go to the general office to be initialled by some responsible person there, and be sent thence to the stores.

The practice in some factories of allowing workmen to go to the stores to get the various goods each requires is an exceedingly bad one.

It wastes a great deal of the time of skilled employees, which has to be paid for, and undermines discipline. There should be a proper and adequate staff of messengers or labourers in the stores to carry whatever goods are requisitioned direct to the different departments. The stores should be quite shut off from the rest of the factory, and no one should be allowed inside except the stores staff and any other persons who are properly authorised to enter.

Replacing Stock. On each shelf or bin or compartment there should be some sort of indicator giving the quantity of stock still remaining. A certain minimum should be fixed for every class of goods, below which the stock must not be allowed to fall; and when this minimum is being approached some sort of requisition form should be sent by the storekeeper to the buying department for the stock to be replenished. Where small nuts, bolts, rivets, and the like form a part of the general stores, these are often kept in large glass jars with coverings. In this way they are preserved free from dirt and dust, and the jars being transparent enable the condition of the stock to be seen at a glance.

Requisition forms should be bound up in books with duplicate sheets, so that each department can keep for reference a duplicate of every requisition it makes out and sends to the stores. The forms should have spaces for setting forth the name of the department requiring the goods, the name of the job they are required for, the signature of the responsible official ordering them, the signature of the head of the department, the date, the signature of the storekeeper when he has executed the order, and any other particulars likely to be needed by the costing department. No stereotyped form can be given that will suit all businesses, as the requirements depend so much upon the size and character of the factory. When the goods have been given out strictly in accordance with the terms of the requisition, the form should be filed ready for the costing department, and a note made on the card-index file, and also on the record attached to the shelf or bin from which the goods have been taken. There should be no delay about this.

Crediting Returns. Sometimes a department will find that it has requisitioned more stores than it requires. It should be made a rule that, directly on the completion of a job, any surplus material should be returned to the stores, and a credit note, which may be on a recognised form, obtained by the department returning the goods. This credit note should be sent to the costing department with the time-sheets of the men engaged on the job, so that the work may be duly credited with the material not used, but already set against it on the original requisition form.

In such businesses as engineering, where expensive tools are used, the stores will take charge of these, and will hand them out to the men each morning, receiving them back at night. Some form of receipt will in such cases be necessary, which can be given by the workmen on taking the tools, and by the stores on receiving them back again at the close of work.

The Manufacturing Department. We next come to the manufacturing department proper, and it is here, in some central position, that the factory manager will have his office. The old system of allowing the office to be a room completely shut off by walls from the factory has given place to an apartment with glass partitions, so that the factory manager can see out into the factory and can be seen by the workpeople. In this way his supervision is continuous, and, at the same time, greater confidence is inspired in the employees when they see that the manager's office is as open to their view as their workshop is to him.

Every business must work out its own system, the main and essential principle always being to inspire loyalty and enthusiasm in the workers, to increase the capacity for output, and to reduce cost as far as possible without reducing efficiency and quality. To this end the factory itself must be perfectly adapted for the work it is to do. It should be well ventilated, kept cool in the summer and properly warmed in the winter. A shivering workman can never be a good worker. The cloakroom accommodation should be convenient and adequate; and where the factory is situated in a suburb or in the country, and many employees come upon bicycles, proper accommodation for the machines must be provided.

In many businesses where foodstuffs are manufactured it is now the custom to retain the services of a trained nurse to question the women employees as to their character and so on, and to attend to any minor accidents that may occur during the working hours. Some room is usually set apart as a kind of infirmary, a rest-room, where first aid can be rendered for cuts, bruises, scalds, and so on, and where girl employees who may feel temporarily indisposed may rest for a time. The cost of such provision is, of course, not great, and it has been discovered by long experience that the cost is more than recovered by increased efficiency and enthusiasm among the workpeople, who appreciate the care thus being taken of their interests.

The Importance of Good Lighting. Lighting is a very important item, especially artificial lighting, and this should be arranged under the advice of experts. It was found in one factory some time ago that about 50 per cent. of the mistakes made by the workers occurred in the winter months, and after four o'clock, when daylight had departed. Experts were called in, and a new and efficient lighting installation fitted up, with the result that a large proportion of the errors were henceforth eliminated. Not only so, but the output of the workers, which was less in winter, was attributed to the same cause, for with the improvement in lighting came an improvement in output. Any light which, owing to insufficient illuminating power or unsuitable position, causes a strain upon the eyesight of the workers is making for inefficiency and disorganisation, and should certainly be remedied without any delay.

Facilities for Moving Goods. Intercommunication between departments should be easy. Where goods have to be constantly moved about, a complete system of trolley-rails should be laid down. Some factories have miles and miles of such rails. Sloping pathways from one level to another are often the means of saving hundreds of pounds in the course of a year by avoiding the necessity of either hydraulic or electric lifts.

Where men and women are both employed, and communication between the departments is necessary, it is the custom in some factories for only certain men to go into the women's departments, these men being properly authorised and marked by some special badge. Any other male employees entering the departments employing women only are punished for a breach of the factory rules. It is obvious that in large factories, unless there is proper and strict organisation in these matters, a lack of discipline is likely to ensue. Some men must go into the women's departments to push trolleys, lift heavy weights, and so on. Strict discipline must, however, be observed if the productive capacity of the factory in every department and as a whole is to be kept at its highest all the time.

Storing and Packing Goods. In food manufactories great care must be taken in the storage of goods, and the factory manager must institute a system that will result in his being informed automatically of anything being wrong in this direction. The cold storage apparatus must receive particular attention and care. Any goods returned because of faults in preservation or packing should go right into the factory manager's office, and he should get detailed reports, if possible, of the employees who packed them, and so on. These will then form an excellent basis for an inquiry into the causes of the faults, with a view to their removal. Such matters are of supreme importance.

The Choice of the Staff. The engagement of workpeople is a very important business, and is receiving far more attention than it used to do. The question of obtaining suitable employees is one which is of far greater difficulty in some districts than it is in others. With works that have grown up in outlying districts the problem is often one of quantity, and workers have to be imported from the nearest large towns; but often in large towns where there is no difficulty about quantity, the quality is so inferior that the manager is sometimes hard put to it to get sufficient labour of the right kind. It may be a question of skill and practical knowledge of a trade, and it may be necessary to import labour from elsewhere. It is in meeting difficulties of this kind that organising ability in the factory manager and his assistants tells. The establishment of Labour Exchanges by the Government has greatly simplified the problem, and these institutions are of high value to employers of labour.

Up-to-date factories are attaching more and more importance to personal character, and even where unskilled workers are concerned greater care is exercised in the selection from applicants than used to be shown. A good many firms now make applicants fill in a form, containing a list of questions inquiring about past employment and references as to character, efficiency, and sobriety. Then, whether the applicant is taken on or not, these forms are duly filed, and in this way there is a record, not only of the previous experience of each worker in the factory, but also a file to which the manager or his assistants can turn to see if an applicant has previously sought employment, and whether his present statements tally with those of a previous application. Such records are extremely useful.

Advertising Vacancies. A word may here be said with regard to advertising for employees. Often the complaint is made that those who reply to advertisements are not explicit enough in their letters, but it should be remembered that many of the advertisements appearing daily are equally inexplicit. Advertisements for employees should be carefully worded, and, while not putting the standard too high so as to drive off some who possibly through self-depreciation will not reply, and yet might be suitable for the positions vacant, should state clearly what the standard is. In this way there will be as little time wasted as possible through reading unsuitable letters and interviewing unsuitable applicants. There are, of course, recognised papers for the advertising of positions in various trades, and it is important that the right channels should be used, otherwise the money spent in advertising for workers is largely or wholly wasted.

The Selection of Foremen and Overseers. Foremen and forewomen are appointed to supervise sections of the workpeople, and over these there are overseers, and then heads of departments, the factory manager being supreme in the works. In selecting foremen, forewomen, and overseers, many things have to be taken into account. They must have a full knowledge of the work being done; they must be of exceptionally good character, and must have a capacity for handling their subordinates. Anything in the way of domineering must end in loss somewhere. Just as it is true in the case of the factory manager, so it is in a corresponding degree of the foreman. He must lead, not drive; he must inspire, not terrorise; and any man or woman who can get more or better work out of a certain number of workers has proved his or her worthiness for a post of trust and responsibility. This being so, there is no worker, however humble, whether in the practical work or the clerical work of the factory, who cannot begin at once to qualify for a better position. Merit and character never counted for so much in business as they do today, and managers are quick to detect who are the subordinates worthy of better positions and greater responsibility.

The Daily Work Reports. Each foreman should make a daily report for his overseer, which eventually goes to the manager's office for filing. This form will record the number of people normally under him; the number at

work during the day; the reasons, if known, for the absence of those who are away; the total number of hours worked; the names of unpunctual workers; the amount and character of the work done; any accidents that may have happened, and any other matters of interest and importance.

It should at all times be understood in every department that any accidents are to be instantly reported to the factory manager's office; and if it is more than a mere cut or bruise, he should personally see the workman injured, so that a proper record of the accident may be made and certified by eye-witnesses. In these days of employers' liability it is of supreme importance that there should be a regular system of recording full particulars of any accidents that may happen.

Checking Output from Machines. In all factories employing many hands and many machines there must be instituted a regular system of checking the rate of output and keeping it more or less uniform, according to the highest standard. Machines must be watched, and their output recorded per hour and per day over a given period, and then the different hours and days compared. In this way any irregularity or weakness will be discovered, and, being discovered, the cause must be found and remedied. It may be in the machine, or it may be in the man; or if it is in neither, it may be in some bad system that is in vogue and that needs bringing up to date.

The Record Department. In the factory manager's office, or attached to it, will be a record department, where, by the card-index system, full particulars are kept of the record of each employee. These cards, filled up principally from the foreman's reports and the time-sheets, will show how many times in the year an employee has been absent, and the cause of such absences; how many times he has been late; the number of times he has been reported for carelessness or insubordination; the number of accidents he has been concerned in, directly or indirectly, and their nature, also whether he has been in any way responsible for them; the amount of spoilt goods due to his carelessness, and his general character for loyalty, willingness, skill, cleanliness, and so on. Attached to this there will be a general report by the foreman, the overseer, and, if possible, by the manager himself from personal observation. It is extremely useful to have such a record properly filed and formulated, for reference in case of any charge against the man by a new foreman or overseer. By having a system of placing the men in classes—say, 1, 2, and 3 for punctuality; 1, 2, and 3 for willingness, and so on—the annual report can be transferred each year very quickly and easily to a more permanent card-file, so that in course of time there is a complete record for each man for the past six or dozen years.

A Disadvantage of "Speeding Up." Years ago, if a staff was fairly efficient and turned out sufficient work to make a profit for the business, the proprietors were usually satisfied, but of late years the organisation of factories and businesses generally has gone on apace, and now, no matter what the profits may be, nor how proficient the factory may seem in all its departments, there is a feeling that every machine and every man, from the manager down to the doorkeeper, is capable of even better things than they have hitherto done. The result is that various systems have been devised to enthuse employees and induce them to increase the quality and quantity of their production.

In America many firms do this by what is known as "speeding up," and this is often little more than a minute sub-division of the work, so that every worker is dependent upon every other worker, and all must keep to a certain pace, or the whole business will be at a standstill. A few very quick and smart workers are then put in at exceptionally good wages, and these set the pace, the great mass of the workpeople having to keep up with them. Such a system does not commend itself in England. It may for a time result in increased output where the labour market is overstocked, and those who fall out of the race can be quickly replaced, but it is bad in that, so far from inspiring the workers with enthusiasm for the house for which they work, it causes resentment, and often hatred, and on such a spirit no permanent success can be built up.

Profit-sharing on the Basis of Efficiency. A better system is that which is largely in vogue in this country and in America, the system of sharing a proportion of the profits with the workers. It is here that the record of the various workpeople described above proves so valuable. The amount of profit for each person has to be allotted on some basis, and a mere wage-basis does not result in the worthiest and most loyal getting the proportion of profits which should be theirs. The system carried out by many businesses is to take the various points of the record into consideration—punctuality, loyalty, efficiency, regularity, and so on—and to base the amount of profits on all these things taken in conjunction. In this way there is a substantial inducement held out to every employed man and woman who is included in the profit-sharing scheme to build up a good record by careful and consistent and loyal work.

Bonuses for Rapid Work. Another method of producing greater efficiency and enthusiasm is by a system of bonuses on work done in less time than the time actually allowed in the estimates. A certain time is reckoned as being necessary for the completion of the job according to normal conditions, but if the work is finished in less time each workman engaged upon it is entitled to a bonus varying in amount according to the length of time saved. If, on the other hand, the job should take longer than the time that was estimated, the workman receives his regular wages at so much an hour; he does not lose anything at all. In this way there is nothing in the system that clashes with trade union principles. The union rate of wages is paid, and every man gets it; but by putting their backs into the work and exerting themselves,

and taking an interest in turning out the job quickly, the men have a certain amount of money which means extra profit on the work. The bonus system really amounts to this—that the profit saved by the speedier work is divided between employers and employees. It is to the interest of every workman engaged on the job not only to work well himself, but to induce and encourage his fellows to do the same, as all alike will benefit. Such a system of bonuses on time saved is particularly applicable to trades like engineering and building.

There are various ways of reckoning or allotting these premiums. They are usually 33⅓ or 50 per cent., and the following table shows how they work out according to whether the time saved is much or little :

WITH A PREMIUM OF 33⅓ PER CENT.

Time xpended.	Wages per job.		Pre-mium.		Total labour cost of job to employer.		Profit of employer.		Work-man's hourly earnings.	Per centage of increase in wages.
Hours.	s.	d.	s.	d.	s.	d.	s.	d.	Pence.	%
10	10	0	—		10	0	—		12	—
9	9	0	0	4	9	4		8	12·44	3.7
8	8	0	0	8	8	8	1	4	13	8.3
7	7	0	1	0	8	0	2	0	13·71	14.29
6	6	0	1	4	7	4	2	8	14·66	22.2
5	5	0	1	8	6	8	3	4	16	33⅓

WITH PREMIUM ON SCALE OF 50 PER CENT.

10	10	0	—		10	0	—		12	
	9	0	0	6	9	6		6	12·66	5·5
	8	0	1	0	9	0	1	0	13·5	12.5
	7	0	1	6	8	6	1	6	14·57	21.4
	6	0	2	0	8	0	2	0	16	33⅓
	5	0	2	6	7	6	2	6	18	50

Of course, the more time is saved, the less actual money a man will make out of the particular job, but in a factory where the system is in vogue, the mere fact that there is a desire to speed up the work and increase the output means that there is plenty of work ; and no sooner is one job finished than a man has an opportunity of starting on another. In this way, though the total remuneration per job may be less, the wages per day or per week are far more. Thus, to take an extreme case, and confine it to one man, let us say that he would in the ordinary way do a certain job in ten hours, but by speeding up he does it in five, and in the remaining five hours of a ten-hour day does another job for which ten hours were allowed, then he would on this day, according to the second table given, earn fifteen shillings instead of the ten shillings which would have been his wages had he kept to the estimated time.

The Need for Explaining a System. There are no doubt times and peculiar circumstances when all systems break down, but this bonus system has the advantage of having been tried for a long time past, and it is generally recognised as a good one, which is more and more coming into vogue. The more efficient a workman is, the more he welcomes it, as giving an opportunity for the profitable display of his efficiency. But the system is useless unless it has the force of an enthusiastic manager behind it, and is thoroughly explained to the men.

Whatever system of inducements is held out to the workpeople, a thorough explanation of what it means to them is necessary. In many factories meetings are held, and the system about to be brought into use is explained by the factory manager, or perhaps by the managing director. Questions should be invited at such meetings from those who are not clear on any points. Another method of explanation is to put the whole thing clearly into writing, and to have a private circular printed for distribution among the employees, who are to understand that the document is for their own perusal alone, and is not to be shown to anyone outside the firm.

Inviting Suggestions from Work-people. An excellent way of getting the intelligent interest of the workers is to invite suggestions from them for the better working out of the details of the factory organisations. In some factories boxes are fixed up in each department, and any suggestions may be written out, folded up, and placed in the box. At intervals—say, once a week—the boxes are cleared and the suggestions considered by the managing director, factory manager, or any other head who may be appointed for the purpose. Money rewards, varying in amount, according to the value of the suggestions, are offered to the employees for any suggestions that may be adopted. In this way many useful hints have been obtained, and the firm has benefited as well as the workman. Every brain is, in such a case, thinking for the business.

The Factory Acts. All such departments of the factory as the export, shipping, packing, etc., must be efficiently organised, but they are dealt with in other parts of the Business Section of this book. One other matter, however, must be referred to here. The factory manager, and all who work under him in positions of authority, and also those who aspire to such positions, should get copies of the various Acts of Parliament bearing on factories, and study them carefully, for much of the organisation of the factory has to be based on these Acts. There is the Factory and Workshop Act of 1901, an extract of which must be exhibited prominently at the entrance to every factory or workshop. This extract must bear the names of the factory inspectors for the district, and of the visiting surgeon. The working hours must be clearly set forth, and only after an inspector has been notified on an official form may these be altered. The Act provides for the safe fencing of machinery, for the periodical inspection of boilers, for the notification of accidents, and for the conditions in which overtime may be worked. The Workmen's Compensation Act, the Employers' Liability Act, and the Trade Boards Act should all be carefully studied.

By working on the lines suggested, making himself acquainted with all the details of the operations, and inspiring his staff, high and low, the factory manager will improve the efficiency of his factory and increase the quality and quantity of the output, thus increasing the profits of the business.

CHARLES RAY.

Nature of Sound. The Echo. Sound Waves. Noise. Pitch. Harmony. The Scale. Resonance and Vibration. The Human Voice.

A STUDY OF SOUND

For convenience we shall use the word *sound* to indicate the external fact which gives rise in us to the sensations of sound; but meanwhile we must recognise that if there were no ears to hear there would be nothing such as we understand by sound. Apart from the hearing subject, all nature is silent; just as, apart from the seeing subject, all nature is in darkness. One kind of wave-motion, falling upon one kind of nervous structure, produces light; another kind of wave-motion, falling upon another kind of nervous structure, produces sound.

Our first assertion, then, is that sound is a wave-motion. In familiar instances, as in the case of a bell, we are aware that the body which emits the sound is itself, as we observe when we touch it, in a state of vibration. And we can easily convince ourselves by experiment that the essential consequence of such vibrations is to produce disturbances in the medium surrounding the vibrating body. Commonly, that medium is air, but it may be any other substance that possesses elasticity. The essential part played by the air in ordinary cases of the transmission of sound may readily be shown by sounding a bell within an air pump, and then gradually reducing the quantity of air surrounding the bell. When a certain rarity of the air is reached, the sound of the bell ceases, since there no longer remains sufficient air surrounding it to transmit its vibrations.

The Speed of Sound. Every kind of wave requires a certain amount of time for its transmission. This is true of the waves in the ether, which constitute radiant heat and light and electricity. These all travel at one and the same unchangeable speed. As everyone is aware who has watched cricket or firing from any distance, the speed of these ethereal waves is far greater than that of sound. One sees the bat hit the ball, or the puff of smoke appearing, appreciably before one hears the corresponding sound. The speed of sound can readily be calculated, and, unlike the speed of ethereal vibrations, is found to vary according to the state and properties of the medium which transmits it. The speed does not vary markedly, however, with the pitch of the sound, which we shall shortly study, nor yet with its loudness—facts which are fortunate for the musician.

All sounds travel through air at a speed of rather more than 1,100 ft. per second, the speed increasing somewhat with the temperature of the air. The reason of this is found in the fact that such a rise of temperature increases the elasticity of the air, and it is upon this factor that the speed of sound in any medium depends. The speed of sound in other media than gases has also been studied, as also the relative ease with which such media transmit it. We know that the earth will transmit sound more efficiently than the air above it; this every boy knows who has read of the exploits of the Red Indians and the ease with which they acquaint themselves with the approach of their enemies by putting their ears to the ground. In general, sound passes much more rapidly through solids than through liquids, and through liquids than through gases, including, of course, the air. Thus, sound travels through iron about seventeen times as fast as through air.

The Intensity of Sound. The intensity of sound varies according to a law with which we must now be familiar, since it holds true for radiant heat, for light, and for gravitation. The law is that *its intensity varies inversely as the square of the distance.* This is familiarly known as the *law of inverse squares*, and is true of wave-motions in general. But the intensity of sound varies also with another factor which has not to be reckoned with in the case of ethereal wave-motions; and that is the density of the medium which transmits it. We know, for instance, how clearly sounds are heard on a frosty night, the reason being that the air is then more dense; while a famous Alpine traveller mentions that the report of a pistol at a great elevation appeared no louder than would that of a small cracker at a lower level.

Just as other wave-motions are reflected, as we saw in the case of radiant heat, so are those which we interpret as sound. The laws of such reflection are the same as those that regulate the reflection of light; and, indeed, are the same as those which (ideally) determine the reflection of a billiard ball from a cushion. The angle of incidence is equal to the angle of reflection, and, we must add in the case of sound, the planes of incidence and of reflection coincide. These laws are equally true for the reflection of light and radiant heat.

Everyone who has ever heard an echo is aware of the reflection of sound. Echoes sometimes offer serious practical problems, since they may seriously interfere with the utility of a hall for music or public speaking. In order to correct this defect it is necessary to break up in every possible way all the sound-waves except those which actually travel directly from speaker or performer to the audience. Wires and tapestries, and, indeed, the bodies of the audience themselves, are often found to be of value.

Use of an Echo. But the principle of the echo may also be utilised in a rather surprising way. If the sound be reflected from more than one surface there will be a series of reflections, or echoes, which will remarkably modify the

ordinary facts of its transmission. A familiar and conspicuous instance is furnished by the whispering gallery of St. Paul's Cathedral. Similarly, sound may be reflected from smooth sheets of ice, as in the case of two Arctic explorers, who conversed comfortably at a distance of a mile and a quarter. The principle of repeated reflection is adopted in the ear trumpet, the speaking trumpet or megaphone, and in all kinds of speaking-tubes. The most striking natural instances of echoes are furnished by peals of thunder.

Refraction of Sound. Just as light waves, as we shall afterwards see, are bent or refracted on passing from one medium to another, so also are sound waves. In the case of light and radiant heat, we have to remember that the wave is passing through one and the same medium all the time; but in the case of sound the wave is actually transmitted from, let us say, the air of one room to the wall of another, and so to the air of the next. But in such cases the direction in which the new wave travels is different from the previous one. This change of direction is indicated by the term *refraction*, and it follows the same laws for sound as for light, under which they will be discussed. Just as light—in virtue of refraction—may be brought to a focus by a convex lens, so also may sound by the employment of some medium which will refract it. A balloon filled with carbonic acid gas, for instance, will bring to a focus at a definite point on one side of it the sound of the ticking of a watch placed on the other side of it. If the balloon be made to swing from side to side, as in the case of an experiment of Lord Rayleigh's, the demonstration is still more striking.

Nature of Sound Waves. We have already noticed one fundamental distinction between the waves of sound and those of light—*viz.*, that the former are waves in a material medium (which may be gaseous, liquid or solid), while the latter are waves in the ether. But another most important distinction is that these ethereal waves or vibrations are at right angles to the line in which they advance. They are described as transverse vibrations. But the waves of sound are longitudinal vibrations. The particles of air, or whatever the medium may be, travel to and fro in the line in which the whole wave is advancing.

Now, a most important distinction between these two waves—transverse and longitudinal—is that the latter, unlike the former, bring the particles of the medium alternately nearer to, and farther from, one another than they are when undisturbed. Such waves are thus waves of alternate condensations and rarefactions. Perhaps one of the best ways in which to obtain an idea of such waves is to think of a row of billiard balls in contact with one another; the ball at one end being struck by another ball rolling up against it. The balls, being elastic, like all media which transmit sound, are alternately compressed and recover themselves, with the ultimate result that the ball at the end of the row is shot forward by itself. In just such a manner must we imagine the particles of air to behave when transmitting sound.

Noise. But there are sounds and sounds, as everyone knows, and though opinions differ as to the precise point where the line should be drawn, there are two great classes of sounds between which our ears detect so marked a difference that there must surely be some objective difference, equally definite, between them. Sounds we may divide into noises on the one hand, and musical notes on the other. What is the difference between them? This question can be clearly and positively answered. The vibrations which we interpret as noise are irregular, while those which we interpret as musical notes are regular. In observing this fact, we make a most important contribution to psychology. The psychologist asks why one sound is pleasing and another unpleasing? As physicists, we reply that, while ignorant as to the manner in which hearing is effected, we know the pleasing sound to be determined by regular stimulation of the nervous structures by which we hear, while unpleasing sounds, those which have not the musical quality, are determined by irregular stimulation. We need pay no further attention to noises of any kind, but must now devote ourselves to the study of musical notes—the fashion in which they are produced, and their relations to one another.

Pitch. The most striking respect in which musical notes differ from one another is in pitch, and it is easy to ascertain by what this is determined. It depends simply upon the number of shocks upon the ear per second. A tuning-fork, for instance, can be made to record its vibrations upon a piece of smoked paper passing in front of it, and we find that the pitch of the fork depends upon the rate at which its prongs vibrate. For any particular tuning-fork this rate is constant. As we listen, we hear the sound gradually die away; but the wavy line upon the smoked paper shows us that the number of vibrations per second does not vary; while our ears tell us, in point of fact, that the pitch remains constant even while the loudness diminishes.

The matter of *loudness* is so simple that we may dismiss it here. It depends merely upon the size of the waves, their extent, or, to use the technical phrase, their *amplitude*. The behaviour of the ear, however, somewhat complicates this statement, since Helmholtz, the great German physician, physicist, and philosopher, observed that the notes differing in pitch differ also in loudness, even where the amplitude of vibration is constant, the higher note always exhibiting the greater intensity. This is simply to say that, other things being equal, our ears are more sensitive to high than to low tones; but, in the case of any given note or tone, its loudness depends simply upon the amplitude of the vibrations which constitute it. So much for loudness. The essential fact of pitch we have already determined to be the rate of vibration. Various instruments have been devised for proving this assertion, and also for elucidating the facts of harmony. There is

for instance, what is called the toothed wheel apparatus of Savart; but that has now been superseded in practice by another device.

The Siren. This is the name of an apparatus by which a continuous flow of air through a tube is arrested and permitted at regular intervals by means of a revolving disc, near the edge of which are a number of holes at equal distances from each other. These holes come in succession opposite the end of the tube, and permit the air to escape. In a more complicated form of the same instrument there is an arrangement by which the speed at which the disc rotates can be readily measured.

When we experiment with such a siren, we find that the note which it produces rises or falls according as we increase or diminish the speed at which the disc rotates. But it also gives us much further information. In the first place, it gives us the limits of hearing for any individual—limits which are precisely comparable with those of sight. When the number of puffs per second is 10, let us say, individual puffs may be heard, but there is no note produced. As the speed of the disc increases, however, a note is heard, perhaps when the puffs reach the figure of 16 per second. The first note heard has, of course, an extremely low pitch, but as the number of puffs per second increases the pitch rises, until at last it becomes extremely shrill, and finally is lost altogether. The number of vibrations beyond which no further sound is heard may be 30,000 per second or 50,000 or 70,000. The figure varies with different individuals, and is also affected in any individual by the occurrence of various kinds of deafness. The upper limit of hearing, for instance, may be very much reduced in cases of what is called *nerve-deafness*, where the disorder is due not to the conducting apparatus, but to the nervous centres themselves. Thus the siren may be of considerable medical importance. It is very probable that sounds too shrill for most or for all human ears may be perfectly audible for some of the lower animals.

The Harmony of the Siren. In order to study harmony by means of the siren, Dove, of Berlin, has modified the instrument, piercing four concentric sets of holes in the disc, the number of holes having, for instance, such a ratio as 8, 10, 12, 16. He calls this the *many-voiced siren*, and can cut off any particular circle of holes at will, thus making the instrument speak with any combination of its voices. It is then found that if the eight and sixteen-holed circles be left open, two tones are heard, one an octave above the other. If the speed of rotation of the disc be accelerated or reduced, the tones are proportionally sharpened or flattened, but the one always remains the octave of the other, proving conclusively that the relation between a note and its octave depends upon the fact that the speed of vibration is exactly twice as fast in the one as in the other. Now, the ratio of 8, 10, 12, and 16 is the ratio of 4, 5, 6, and 8, and if all the circles of holes be left open, that is the ratio between the four notes which are produced. These are the notes of what musicians call the *common chord* or *fundamental chord* C E G C′. If the first and third series of holes be left open, we find that the note having the ratio of 6 to 4 or 3 to 2 is a fifth higher than the lower note. The G on the piano thus has half as many vibrations again per second as has the C below it, the ratio being that of 6 to 4 or 3 to 2. Similarly, we find other musical intervals established by sounding other combinations of the circles of holes, and it is an easy matter to establish the ratios of all the notes in, for instance, the ordinary major scale of C. Thus:

$$C : D : E : F : G : A : B : C'$$
$$1 : \tfrac{9}{8} : \tfrac{5}{4} : \tfrac{4}{3} : \tfrac{3}{2} : \tfrac{5}{3} : \tfrac{15}{8} : 2$$
$$(\text{or, } 24 : 27 : 30 : 32 : 36 : 40 : 45 : 48)$$

The Scale. The most important fact about such a scale is the constancy in the ratio between its notes. In fact, we must state, as follows, the fundamental law of musical harmony. *The notes employed in music always correspond to certain definite and invariable ratios between the vibration numbers of the notes; and these ratios are of a very simple kind, being restricted to the various permutations of the first four prime numbers*, 1, 2, 3, 5, *and their powers.* This fact is the whole essence of music, not only of harmony but of melody also. All the notes of any tune must lie in a definite scale, the nature of which is determined by the strictest mathematical considerations. Music is thus a variety of applied mathematics. If a note be sounded which does not possess one of these due simple ratios to the other notes of the scale, we say that it is out of tune—*i.e.*, it is either *flat* or *sharp*. The note may have pleasant enough quality in itself, but it has no relation to the rest of the notes of the piece. It simply cannot occur in such a place. This fact is quite distinct from all questions of discord. Almost any discord is permissible in its place in modern music, but all the notes so sounded have, at least, their regular places in the scale, whereas a note which is "out of tune" has no such place. The various notes of the scale quoted above constitute what is technically known as the *natural* or *diatonic* scale.

The intervals between successive notes upon this scale are either major or minor tones or semitones, the third and the seventh belonging to the latter class. If we insert an additional note between each pair of notes whose interval is either a major or a minor tone, we obtain a sequence of twelve notes, the intervals between each successive two of which are much more nearly equal than those of the notes in the diatonic scale. This more complicated scale is known as the *chromatic* scale. The distinction between the older music and the music which is most prominently represented by Wagner may most simply be stated by saying that the older music is founded upon the diatonic and the newer upon the chromatic scale.

Stretched Strings. The facts which can be so easily proved by the siren can equally well be demonstrated by several other means. Notes of varying pitch may be produced, for instance, by the vibration of stretched strings.

Certain conditions determine the note which is produced by any given string, these being its length, its mass, and its tension. The term *mass* covers two factors which may vary independently—the thickness of the string and its density. The simplest of these factors to understand is the length of the string. If a string, as in a violin—its tension being kept invariable—has its length altered, its fundamental note (we shall afterwards explain the meaning of the word fundamental) will rise in pitch in exact proportion to its diminished length. In this fashion, the diatonic scale can be played on one string of the violin, by stopping at intervals corresponding to the notes required.

Tension and Pitch. The relation of the tension of a string to its pitch is rather more complicated. Other things being equal, the note is proportional to the square root of the tension—that is to say, if the tension be multiplied by four, the pitch of the note is multiplied by two—it is raised an octave. Again, the note of a string varies inversely as the square root of its density, and inversely as the square root of the weight of any given length of the string. There is no simpler arrangement for studying these facts in the case of strings than the monochord, which was known to the Greeks and carefully studied by them. This is simply a single string stretched between two fixed points over a sounding-board. Between the ends of the string is a movable bridge, by means of which the vibrating length of string can be modified. For instance, if the movable bridge be inserted half-way along the string, the result is a note an octave higher than when the bridge was absent, and so on. So far as we have gone we find that the facts agree entirely when we turn to the notes produced by pipes instead of strings. Other things being equal, a pipe of eight feet in length will produce a note an octave higher than a pipe sixteen feet in length.

Fundamentals and Over-tones. But we find a great deal more complexity in, for instance, the vibration of a stretched string than has hitherto been indicated. The string, it is true, is vibrating as a whole, but it is also vibrating in segments. The same is true of a column of air in an organ pipe. The note produced by the vibration of a string as a whole is known as its fundamental note or tone. The notes produced by its simultaneous vibration in parts are known as *over-tones* or *harmonics* or *upper partial* tones.

These over-tones are of immense interest and importance from every point of view. We have already noted one or two characters in which one musical tone or note differs from another—characters such as pitch and loudness. But there is another character, at least of equal interest, which is quite independent of both of these, and that is the quality or *timbre* of the note. Various words have been used for expressing this quality. Sometimes we employ in English, the word *clang-tint*, a translation of a German term. Any two tuning-forks sounding notes of the same pitch and loudness are absolutely indistinguishable from one another. The reason of this is that the note produced by a tuning-fork is a simple tone containing only one fundamental note without any harmonics or over-tones.

How Notes and Tones are Identified. This fact, then, leads us to understand how it is that we are able instantly to distinguish identical notes, or what purport to be identical notes, according as whether they are produced by a piano, a violin, a clarionet, the voice of one friend or the voice of another. We say these notes purport to be identical, and, indeed, their fundamental tone is identical. The differences which enable us readily to distinguish them so are entirely dependent upon the number, character, intensity, and intensity relatively to one another, of the various over-tones which accompany the fundamental note in every case. If these be few, the tone is thin and lacking in beauty; if they be very numerous and prominent, the tone may be very heavy; and sometimes, as in a very rich and resonant bass voice, the identity of the fundamental tone is actually obscured. The finest tone is that which includes the largest number of over-tones, or harmonics, that form a fine harmony with the fundamental tone. If the over-tones form an unpleasant chord with the fundamental tone, then the voice or violin, or whatever the instrument may be, is held to be unattractive.

Resonators. Everyone knows how a sound produced by any means is reinforced under certain conditions. Illustrations are furnished by a watch lying respectively on cotton-wool or on a hard table, and by a tuning-fork held in the air or having its stem firmly placed upon a table. The string of a piano produces extraordinarily little sound when struck unless it be aided by a sounding-board. If the belly of a violin be removed for experimental purposes and the instrument then played, it is impossible to get any fine tone out of it. The tone is, indeed, thin and offensive. Indeed, every kind of musical instrument is provided with some device or other in order to reinforce the sound which it produces. Such devices are known as resonators, and they are of extreme importance in music of all kinds, including vocal music. The manner in which a resonator acts is by increasing the amount of air which is thrown into vibration.

Science of Resonators. When, for instance, the stem of the sounded tuning-fork is placed upon a table, the table itself vibrates at the same rate as the fork; and consequently a very much larger amount of air is set in motion. The rule with resonators is that there are certain tones which they best reinforce. A series of resonators can be made, indeed, such that each responds to a given note and to that alone; or, at any rate, if to other notes, only to those of very nearly the same pitch. The selective action of resonators can readily be shown by holding a sounding tuning-fork over a tall cylindrical vessel containing

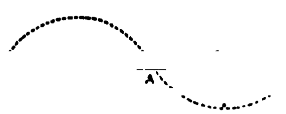
water. The sound is found to be greatly reinforced only when the water in the tube stands at a certain level. This experiment furnishes the proof of a most important fact. Let us suppose that a compound tone is being sounded. The proportion and relative value of its overtones can be almost indefinitely modified by the use of various resonators which pick out and reinforce various over-tones or combinations of over-tones. The immense musical importance of adapting one's resonators so as to reinforce certain selected over-tones will be discussed later.

Harmonics of the String. Let us now return to our stretched string, or monochord. So far it has merely taught us that its note varies according to the length of it that is allowed to vibrate. Now, if, instead of merely plucking the string with the finger, we throw it into what is called forced vibration by means of a violin bow, we discover that more harmonics are produced. Only the very highly trained ear can actually detect them; but everyone is able at least to recognise that a much finer and richer tone is produced by bowing the string than by plucking it. The difference is not a question of loudness, and the note is the same in both cases; it plainly depends upon the presence of over-tones. It is, indeed, found that the string is vibrating not only as a whole, thus producing its fundamental tone, but also in two equal halves, thus producing an upper partial, or overtone, an octave higher, and also in other proportions, corresponding to the interval which is called the twelfth, to the double octave, and so on.

It is the presence of all these additional tones, happily blended with the fundamental tone, that accounts for the superior quality of the sound now produced. Each of the strings of a fine piano acts in precisely the same way, and there is a simple and interesting fashion in which this can be proved. Hold down with the fingers a series of notes on the piano, such as C in the bass clef, the C above that, and also the E, G, and B flat above it; now strike very firmly the low C below the bass clef, and let the note go. Immediately you hear, if the piano be a good instrument and in tune, a soft chord consisting of the notes which you are holding down. (The reason why one has to hold them down is to prevent their vibrations from being damped, as they would otherwise be.) The explanation is very simple. The low tone which was struck contained a number of upper partials; the string was vibrating not only as a whole, but also in segments corresponding to the various over-tones. How do we know this? The only statement that needs to be made for the complete understanding of the experiment is a statement of the fact which is called *sympathetic vibration*, at which we have already hinted in describing the selective action of resonators.

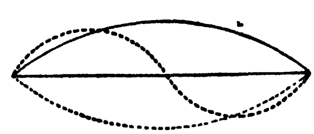
Sympathetic Vibration. The upper strings in our experiment, being left free to vibrate by having their dampers removed, have responded each to the over-tone identical with its own fundamental tone, in just the same fashion as a resonator of a given size and shape responds to a given over-tone in a clang or compound note. The occurrence of sympathetic vibration is not difficult to understand. We must imagine that the case is not dissimilar to the pushing of a child on a swing; a series of taps given at the right moment will soon produce a very decided vibration. In the case of the very best pianos, sympathetic vibration is a very large factor in explaining the quality of their tone, since, whenever the loud pedal is down, all the higher strings that correspond to the over-tones of any lower note that may be sounding are thrown into vibration. For this purpose it is necessary that the piano be perfectly in tune, and the owner of a fine piano but only a moderately fine ear may know that his instrument needs tuning, less because any defect can be definitely observed than because its tone appears to be rather less rich and resonant that he has observed it to be immediately after tuning.

Nodes. If we take the simplest case of an over-tone, the production of a note an octave above the fundamental note, we may imagine—and, indeed, may see—the string to be vibrating in a fashion which is represented by the accompanying diagram. At the point A we have what is called a *node*; the segments of string on each side of it are vibrating in opposite directions, and are technically known as ventral segments.



This is the simplest case but one, the simplest case obviously being that in which the string has but one ventral segment, while its fixed extremities constitute its only nodes. But, indeed, a musical string is susceptible of an infinite variety of modes of vibration corresponding to different numbers of subdivisions into ventral segments. It is the general rule that the over-tones tend to become fainter as one passes upwards. The higher the over-tone, the larger is the number of ventral segments of the string, and the less is the amplitude of their vibrations.

A second figure indicates the state of affairs when a string is giving forth both its fundamental and its first over-tone. It is, of course, evident that no part of the string can be in two places at the same time, as the diagram would at first sight appear to indicate. But, in reality, the motion of the string in such a case is complex, being the resultant of two factors, one corresponding to the fundamental and the other to the over-tone.



The diagram expresses in merely ideal fashion the shape of the vibration that corresponds to each of these. The extreme complexity of the motion of the string when the number of overtones is very large may easily be imagined.

Tuning of Resonators. Helmholtz made many interesting experiments with resonators, and devised a large instrument consisting of a whole series of resonators arranged in a definite order. Any one of such tuned resonators may be used in order to demonstrate, even to an unmusical ear, the corresponding over-tone in a compound note. Each of them is a hollow sphere, with two opposite openings, the smaller of which is applied to the ear. If now the compound tone be sounded, the resonator will immediately demonstrate the occurrence of its corresponding over-tone by greatly reinforcing it. These resonators may be arranged in such a position as to affect flames placed opposite them. When we sing opposite such an arrangement, the movement of the flames, which may be readily made visible by means of revolving mirrors, tells us precisely which over-tones are contained in the note we are singing.

Vibrating Plates. What is true of strings is true of other vibrating bodies, such as plates. The physicist Chladni made a study of this subject by taking square plates, clamping them in the centre, and sprinkling very fine sand upon them. If now the edge of such a plate be bowed, it will vibrate in a particular fashion; and this will vary if the finger be placed upon the plate at various points and accordingly as the position of the bow is altered. The plate has its nodes just as the string has, their position varying with these varying circumstances, and the sand naturally tends to be thrown upon whatever may happen to be the nodes or nodal lines of the plate. Hence there may be produced an endless number of sand patterns, which are everywhere known as Chladni's figures.

Pipes. The principles we have already learnt are applicable not only to stringed instruments but also to wind instruments, such an an organ-pipe or a flute. The column of air in such an instrument is of a certain length, and is capable of vibrating at a certain speed. That we have seen in the case of the column of air above the level of the water in the cylindrical glass vessel which we used when studying the principles of resonators. The differences between various types of wind instruments are extremely interesting, especially to the musician, mainly because each of these types has its own characteristic capacity for the production of over-tones. For instance, what is called a stopped organ-pipe is capable of giving only the odd over-tones—those whose frequencies are three or five times, for instance, that of the fundamental tone. Obviously, the quality of a note produced by such a stopped pipe must be quite different from that given by the open pipe, which is able to yield the complete series of over-tones.

The Human Voice. But the only kind of musical instrument which we have space to discuss here is the human voice—the oldest and most interesting of all. Essentially it is produced in the voice-box, or *larynx*, which is developmentally equivalent to one of the gill arches of the fish. The various cartilages of which it consists are all devoted to the service of the *vocal cords*, which are made of fine elastic tissue, and are practically stretched strings. In front they are attached close together, quite close to the projection which we call Adam's apple. Passing backward they slightly diverge; but the larynx is so constructed that they can be quite closely apposed, so that only a tiny chink is left between them. This the singer or speaker does, and then, by means of a forced expiration, drives a column of air against the resisting cords, which are thereby thrown into vibration. The rate of the vibration or the pitch of the note produced must depend, our study of stretched strings has already shown, upon the tension, length, and mass of the cords. A man's larynx is larger than a woman's; his cords are longer and heavier, and therefore his voice is of lower pitch.

Causes of a Good Voice. The only factor over which we have control is the tension of the cords. If a dissected larynx be caused to emit a note, it is found to be very thin and unpleasant, being what teachers of singing call the "naked tone." But in the case of even the finest singer, no tone is actually *produced* anywhere save in the vocal cords. All the over-tones which make his voice so beautiful are produced by the partial vibration of his vocal cords. What enables him to produce such fine tone is his possession of resonators which are either naturally fitted to reinforce the most desirable over-tones, or else are capable of modification at his will for this purpose.

Voices undoubtedly differ from one another naturally in respect of their quality, the shape of the unchangeable resonators being—in some people—fortunately precisely adapted for purposes of singing; but, in addition, voices vary widely, because of the varying skill with which the modifiable resonators are employed. We all of us have skill enough to modify our resonators so as to produce the various vowel tones, and the singer's skill is only an advance upon this.

The Man of Many Voices. When the teacher tells the pupil how to "place" the voice, what is meant is simply that the muscles of the tongue, lips, and throat are to be so co-ordinated that the best possible resonance is ensured, picking out and reinforcing to the utmost the most valuable of the over-tones in the laryngeal note. But there is a much higher art than this, and one known to only few singers—the art of modifying the vocal colour or quality for various purposes. Plainly, different qualities of voice are required for imprecation, love-making, and defiance. Some famous singers are the possessors of half a dozen voices. Their art consists in their amazing control of all their modifiable resonators, so that, while sounding one and the same laryngeal note, they are able, by variously selecting and reinforcing its various over-tones, to endow it at one time with a sensuous, at another time with a martial, at another time with a devotional quality, and so on. Why various clang-tints should possess such varying significance is not for the physicist to say.

C. W. SALEEBY

Wood and Steel Scaffolding. The Various Systems Employed for Different Purposes. External and Internal Platforms.

SCAFFOLDING

Before any building has been raised far above the ground level, the work will be out of reach of a man standing on the ground, who cannot do satisfactory work at a level of more than 5 ft. at the outside above the ground upon which he stands. Platforms must be erected at successive heights as the building grows, that work may be carried on and material for immediate use may be stored. The term *scaffold* is applied to such platforms and the framework arranged to carry them, to whatever height it may be necessary to reach.

A Bricklayers' Scaffold. A bricklayers' scaffold [64] consists in this country of a temporary framework of circular fir poles of various sizes and lengths, which are lashed together with cords of hemp or of galvanised iron wire. This lashing is termed *tying.* The average size of a pole may be taken to be about 5 in. in diameter, with a length of 30 ft. The frame of the scaffold is formed with a series of vertical posts, termed *standards.* These are placed about 8 ft. apart, and at a distance of 4 to 5 ft. from the face of the wall. The foot of each standard is, if circumstances permit, imbedded for about 2 ft. in the ground; but if it is to stand on a pavement, as in a street, it may be placed in a large tub filled with earth, or, when in position, it may be surrounded with a mass of concrete, the object in either case being to keep the foot of the pole from shifting when side strains are put upon it.

For scaffolds of moderate height each standard consists of a single pole, and may be extended upwards by lashing another pole to it. Where a lofty scaffold is to be erected, the standards may be formed throughout of two poles of unequal length lashed side by side, so that, when extended upwards, the poles will be jointed at different levels, thus breaking the position of the joints and rendering the work stiffer. The lashing of two such poles together is termed *marrying.*

Method of Strengthening the Supports. Similar fir poles are placed horizontally against the standards and are securely lashed to them. These are termed *ledgers.* They are placed at intervals of 5 ft.—which distance is termed a scaffold height—right up to the highest level necessary for the building. To stiffen the structure thus formed, especially in exposed sites, poles are placed diagonally from the base of the scaffold to the top, and are lashed to both standards and ledgers to prevent any racking of the scaffold. In this way a light, strong frame is constructed parallel with the face of the wall to be built. It is not completed before the work starts, but grows with it, the height of standards being increased and additional ledgers added as the height of the building increases.

The lashing of the framework is carried out by means of scaffold cords (which are 8 ft. lengths of manilla rope whipped at both ends) twisted several times round the two poles to be united, whether they are at right angles or side by side. The scaffolder's principal tool consists of a special hammer with a spur projecting from it. In tying, the cord may be twisted round the handle, the head placed against the pole as a fulcrum, so as to draw the cord tight. The cords are fastened off by threading the ends under two or three turns. The hammer is also used for forcing the cord into position. When the lashing is completed, pointed wedges having one side flat and the other round are inserted between the pole and the cord, and driven in to tighten up the joint further and left in position. Such cords are liable to shrink in wet weather, and to stretch again in hot, dry weather, and under such conditions the scaffold must be examined and the wedges tightened up.

The wire cords are not liable to be affected by weather in this way, and can, in most cases, be tied sufficiently tightly without it becoming necessary to make use of wedges.

Platforms. The platforms are formed as follows. The brickwork having been carried up to the level of the top of the fresh ledger, small square timbers, termed *putlogs,* usually split out of birch, about 3 in. square and 5 ft. long, are laid about 4 ft. apart, one end resting for about 4 in. on the brick wall and the other end on the ledger, and some of them, at least, are secured to the ledger.

On these timbers *scaffold boards* are laid side by side; these are usually about 12 ft. long, 9 in. wide, and 1½ in. thick. The square corners are splayed, and the ends are protected with a strip of hoop-iron nailed to the board, which prevents them from splitting. To form working platforms these are laid side by side across the putlogs and the full width from the wall to the ledger, and the ends of the boards are butted one against the other.

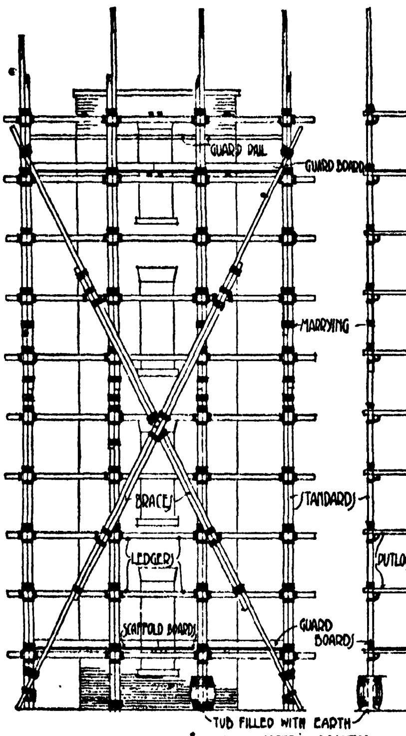
At such joints two putlogs are placed close together, each supporting the ends of one set of boards. Boards sometimes have the ends lapped, but this is not so good a method, and in no case should the end of any board be left without a support under it, or it may tip up if stepped upon and cause an accident. Along the outer edge vertical *guard boards,* to prevent materials falling off, are fixed, and at a height of 3 ft. 6 in. a rail is fixed for the protection of the workmen.

Runs. Runs may also be formed from one part of a scaffold to another, and should not be less than 18 in. wide. These are formed of two boards (or more) laid side by side, and they should be joined together by strips of wood nailed at intervals on the underside.

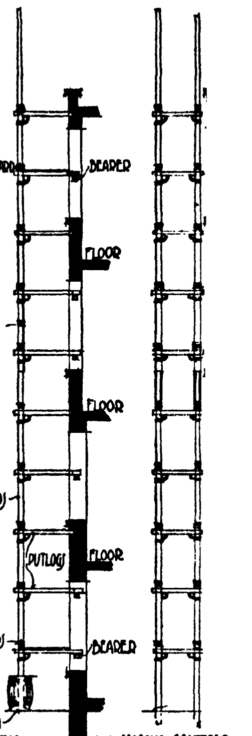
The lowest platform of all is left permanently in position, and, if next a street, must have a double layer of boarding to prevent dust and rubbish from falling through. The other stages are removed successively as the work proceeds, and are re-erected at a higher level.

The foreman must see that the scaffolder prepares each stage in advance of the bricklayers' requirements, so that there may be no delay. As the wall is built up from any stage, a half-brick is omitted, where the putlog rests on the wall. This is known as a *putlog hole*, and is filled in later as the scaffold is taken down. If the *pointing* [see BRICKLAYER] of the wall is left to the finish, the stages must be temporarily reinstated to execute this work, and the putlog holes are filled at the same time.

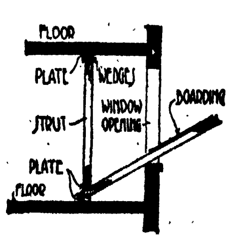
Internal Scaffold. The frame described is assumed to be placed on the outer side of the wall, but a similar frame and platforms must in many cases be erected on the inner side, otherwise the bricklayers would have to work on the inner face *overhand*—that is, by leaning over the wall to set the inner bricks, and such work is not capable of a finish equal to that executed in the ordinary manner. The inside scaffold is often slighter and less complete, and advantage may be taken of cross walls to support the ledgers.



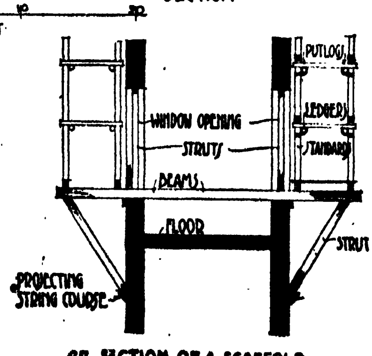
64. BRICKLAYERS' SCAFFOLD



65. MASONS' SCAFFOLD



66. PROTECTING FAN



67. SECTION OF A SCAFFOLD ERECTED ABOUT A TOWER ABOVE THE GROUND LEVEL.

Cross Bracing. In addition to the bracing already described in the plane of the framework, it is desirable wherever inner and outer frames are employed to tie them together.

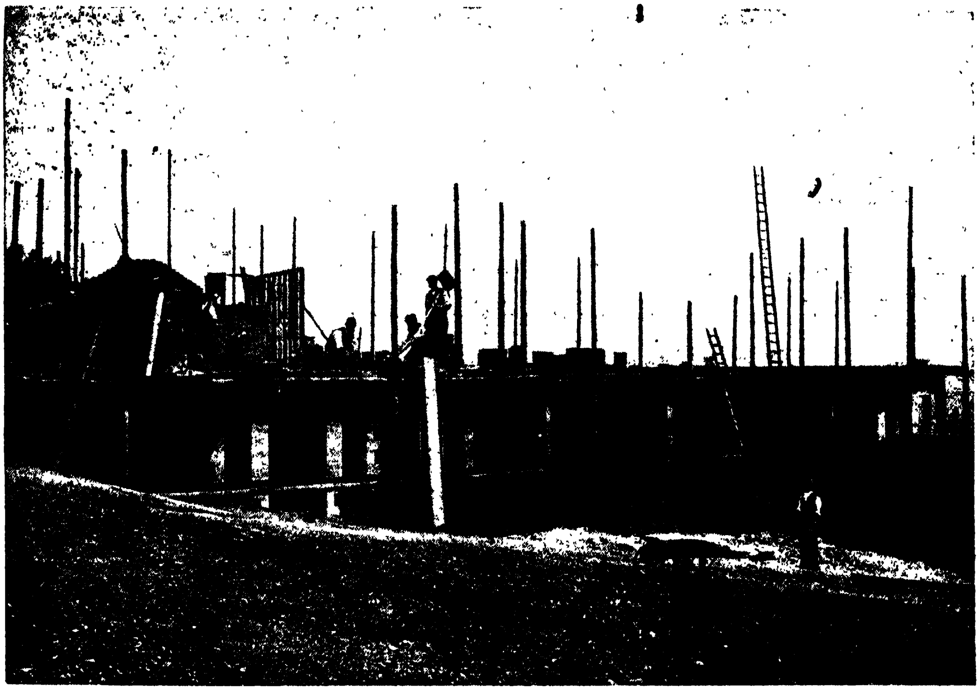
This may be done where door and window openings occur, and contributes to the rigidity of the scaffold, and particularly in exposed situations helps to resist the action of the wind, which often tends to force the whole scaffold out of the perpendicular. On open sites poles may be erected in the form of raking struts to steady the outer scaffold when it cannot be tied to the inner one.

A Masons' Scaffold [65]. A masons' scaffold resembles a bricklayers' scaffold, but when a wall is built of large stones, there are no longer the facilities afforded by brickwork, of forming putlog holes to take the inner ends of the putlogs, and two frames are required, one usually about 5 ft. from the wall and the inner one about 6 in. only from it.

The materials to be dealt with are often much heavier than in the case of brickwork, and the standards may be placed nearer together and braced more rigidly to provide adequate support, and they must be secured so that there is no risk that they will lean away from the face of the wall.

The illustration [64] shows a scaffold suitable for the erection of a small building of considerable

SCAFFOLDING ON A COUNTRY HOUSE



A GENERAL VIEW OF SCAFFOLDING IN THE EARLY STAGES OF HOUSE-BUILDING

It should be noted that the bricklayers are working on a platform carried by the second row of ledgers, the platform carried by the lower ledgers having been removed.

SCAFFOLD SHOWING A RETURN ANGLE

SCAFFOLD WITH RETURN TO UPPER PART ONLY

In the left-hand picture the standards, ledgers, putlogs, diagonal braces, and the method of securing the ledgers to the standards should be noted; in the right, the method of forming the return, and the platform formed of scaffold-boards.

height in proportion to its width, such as a detached sanitary tower of a hospital.

Access to various parts of the scaffold is provided by ladders. They are made of various lengths, and are described by the number of rungs they possess. Very long ladders are often used for repairing and painting work, but in connection with scaffolding, ladders of moderate length are used. Where a great height has to be reached, several ladders are employed, and a platform is provided on which to land from each before climbing the next. The foot and head of each ladder must be firmly lashed or otherwise secured, and a strut is provided from the scaffold about the centre of the ladder to prevent oscillation.

Hoisting Material. Materials are often carried up by labourers in hods or baskets. For larger buildings, the height of which is not great, a kind of well-hole or run is provided at some convenient spot, and lined with scaffold boards placed vertically to enclose it on two or three sides. Materials are hoisted in barrows or baskets by means of a pulley and windlass worked by hand or by a small engine. For large works one or more derrick cranes are used, and by their means materials can be hoisted from carts and deposited directly at any desired spot. Small materials such as bricks are packed in crates and hoisted in bulk. Large stones, timbers, ironwork, etc., are dealt with separately, and great care must be taken to see that they are properly secured before they are lifted.

In executing repairs, a scaffold may sometimes be erected round the upper part of a building without being built up from the ground. In the case of a tower, for example [67], strong beams may be passed through any suitable opening, extending from side to side of the tower so that the load on the two ends will counterbalance and form a base on which a scaffold may be constructed. The outer ends of these timbers may often be strutted from a projecting string course at a lower level. Where the beam cannot or is not required to pass right through the building, the inner end must be secured against any tendency to tilt up by being strutted against an upper floor as in 66.

Protecting Fans. Where such work has to be executed adjoining a public thoroughfare, and where old buildings are being pulled down, wooden fans are often formed for the protection of the public [66]. They are constructed in the manner just indicated; bearers are passed through the available window openings but are not placed horizontally as for a scaffold, but inclined upwards, and the inner ends are securely fixed. The outer ends are covered with boards or cross bearers may be fixed, if required, to receive the close boarding.

The Use of Sreel in Scaffolding. Steel scaffolding, known as Humphries' scaffolding, is, however, now being used to a considerable extent, and has several advantages over the timber scaffold. It is incombustible and, with proper care, almost imperishable; it occupies little room for storage and is easily handled, and quickly and cheaply erected and dismantled. This scaffold is formed with standards of angle iron, the edges of which are notched; they are made in 16 ft. lengths, and may be extended to any required height by means of fish-plates, which are bolted on at each junction. Special clips and wedges can be fixed at any required level, owing to the notched edges of the standards, and these receive the outer ends of the putlogs, which are formed of bars of steel. The inner end of the putlog is reduced to the width of one-quarter inch, and thus occupies the breadth of a mortar joint, and the under side has a projecting nib which hooks over the brick of the course on which it rests, so that the putlog also forms a rigid tie securing the standard, which is further stayed laterally by a diagonal rod at every scaffold height.

The standards are spaced at intervals corresponding with the length of scaffold boards in use, and in place of the ordinary ledger a scaffold board on edge is employed and clipped to the standards, and, where required, intermediate putlogs may be suspended from this by special hangers to support the platform, which is formed of scaffold boards in the ordinary way, but the boards are usually overlapped at the ends. The standards are not imbedded in the ground, but rest on planks. No putlog holes are formed, but when the putlogs are withdrawn the mortar joint only has to be filled in.

Steel Scaffolds Used in Repairing. A steel scaffold frame is also in use for executing work to existing walls, such as pointing or repairs, and can be attached to any part of a wall at any height without the necessity of raising a scaffold from the ground level. It consists of two parts. The first is a grappler terminating in a socket which can be inserted in any vertical brick joint after the mortar has been raked out.

The second part consists of a triangular frame formed of steel bars secured together, of which the horizontal member has a hooked end that can be dropped into the socket while the heel the frame rests against the face of the wall below. This must be free to move downwards slightly when loaded, and must on no account rest on a projecting ledge. These brackets are made of different scantlings, according to the strength required, but a pair of the lightest pattern are designed to carry a load of 7 cwt.

The stronger type of bracket may be used to support the steel standards already described when a scaffold is required for such purposes as raising an existing wall, avoiding the necessity of a scaffold from the ground level.

Sling Scaffolds. Sling scaffolds, or boats, are used especially for painters' work. They require a strong projecting beam fixed above the level at which work is to be executed. From this a small stage or platform, protected by rails and large enough for one or two workmen, is suspended by cords and pulleys, and can be raised and lowered at will. The cords and tackle used for hoisting such boats must be thoroughly examined periodically to see that they are in a perfectly sound condition.

R. ELSEY SMITH

A Survey of Man's Neighbours in the World and how they are Disappearing from the Earth.

THE MARVELLOUS PAGEANT OF LIFE

In an early year of the twentieth century the enterprising editor of a daily newspaper addressed inquiry to a number of persons, inviting their opinion as to which English writer had most powerfully influenced the general trend of thought in the century that had just come to a close.

Not a question to be answered off-hand, one will see; but, after giving it the consideration it deserved, I wrote without hesitation the name of Charles Darwin. Some there be who will demur to such pre-eminence being given to a mere naturalist over the great theologians, historians, philosophers, moralists, poets, essayists, novelists, and men of science of the later Georgian and Victorian eras, many of whom made enduring impression upon their respective provinces of intelligence; but none of these had to overcome such determined opposition from students in the other departments of human knowledge; none could claim a victory so decisive, or one that was to affect so profoundly the methods and conclusions of workers in widely different fields of intellectual energy.

All men acknowledge that Darwin, surveying the products of scientific research accumulated by preceding generations, checked some, rejected others, and verified many of them by laborious personal observation, and, having carefully collated with them the result of man's deliberate interference with the reproduction of domestic animals, lifted the scheme of biology into a higher plane, presenting animated Nature in a novel and startling aspect.

The result, as affecting the ordinary, unscientific lover of Nature, has been to impart a deeper interest to the pageant of life, to give a new significance to the deadly struggle for survival which has been maintained for ages beyond our power of numeration, and to explain the purpose of the merciless suppression of unfit types and individuals.

Ruthless stringency in eliminating the unfit results in the uniform vigour and energy of what we term the lower animals. Epizootics—diseases that from time to time decimate, and more than decimate, the more fecund races of animals—leave the survivors fitter than ever to maintain the struggle, and epidemics among human tribes in a state of barbarism have a like effect. One is apt to recognise in this a teleological purpose, the periodical elimination of a large percentage of consumers in the interest of the survivors and, through them, of the race. It is only in the human community that diseased or enfeebled individuals are permitted to exist and transmit their infirmities to their offspring. When a wild creature loses the power of sustaining itself, the end is not far off. Animals that will freely risk their lives against any odds in defence of their young show the utmost indifference to the evil plight of their fellows, in some cases attacking a wounded comrade and hastening its demise.

It is only within recent times that modern appliances and research have brought to our knowledge how life in one form or another pervades every spot in this globe that is capable of sustaining it. It exists even under conditions which might excusably have been pronounced incompatible with it. Mr. James Murray, biologist with Sir Ernest Shackleton's Antarctic expedition, sank a shaft through fifteen feet of solid ice to the bottom of a coastal lake, and brought up swarms of rotifers and water bears (Macrobiotus). Now, this lake never thawed during the two summers which the explorers spent there; it may have been frozen solid for years or even for centuries, during which these creatures had been embedded in a temperature of forty degrees (Fahrenheit) below zero, incapable, of course, of discharging any of the functions of life. Yet no sooner were they brought to light and placed in water than the rotifers began scooping in floating atoms of food, and they, as well as the minute rhizopoda and water bears, set about at once the process of reproduction, either viviparously or through egg-laying.

Now, these microscopic creatures are far removed above the lowest forms of life. The so-called water bear, for instance, has a simple, but segmented and perfectly symmetrical structure, the sexes of the individuals being distinct and separate. It has eight legs, armed with effective claws, teeth hardened at the tips by a calcareous deposit, a blood fluid containing numerous corpuscles, a stomach, a brain and nervous system, an alimentary canal, an excretory orifice between the hindmost pair of legs, sometimes a pair of eyes, but never a heart. Although it never exceeds one millimetre in length (25½ millimetres = 1 inch), it is the host of many bacteria which infest its blood.

No man need blush to own macrobiotus among his "poor relations," for there does not exist a more harmless race than these minute creatures, which prey—for nearly all forms of life prey upon other forms—only upon mosses and algæ, nibbling through the cell-walls of these humble forms of vegetation and imbibing the sap. But one cannot without a shudder recognise affinity with another class of animal, not distant of kin from the gentle water bear, suggesting the fancy that there have been two creative agencies at work—one, a benignant Deity, designing channels through which the vital force shall be moulded into more perfect beauty and nobler form; the other, a malignant demon, intent upon devising subtle and corrupt instruments for defacing, maiming, and destroying the handiwork of the rival Power.

Malignant Creatures that Infest Animals. The life-history of the pentastomids shows how the perpetuation of every living animal involves the affliction, and often the sacrifice, of some other form of life. These pentastomids are loathsome creatures, inhabiting the nostrils or lungs of dogs and other carnivorous animals. Their eggs or larvæ, being expelled by coughing or sneezing, fall on grass or other herbage, and depend for development upon being swallowed by some browsing creature. When this happens, the larva, which is furnished with clawed limbs, bores through the walls of the stomach, and penetrates to the liver or some other principal organ, where it ensconces itself for several months. As the time for assuming its adult form approaches, the creature begins wandering through the tissues of its host, sometimes causing dangerous and even fatal disturbance. If the said host—be it sheep, deer, rabbit, or what not—is devoured by a dog or other beast of prey, the larva, when swallowed, travels into the lungs or nasal cavity of its second host, where it awaits its development into an adult, and the unlovely cycle is renewed. Note that pentastomids are quite distinct from the cestodes, or tapeworms, which they greatly resemble in haunt and habit. The cestodes are far lower in the scale of animated Nature than the pentastomids, being hermaphrodite, destitute of a digestive tract, and absorbing nutriment by soaking in the dissolved food in the intestines of their host; whereas the pentastomids are bi-sexual, the males moving about freely in quest of their mates, and live by sucking blood from the internal organs wherein they lodge.

Plants that Prey on Animals. All animals depend on plants for their food, either directly or indirectly, but the vegetable kingdom is capable of reprisals, not merely in the vindictive sense of poisoning their foes, but by making them their prey. Bacteria, a humble form of vegetable life, are the direct agents in many, probably in most, forms of acute disease. Also, several of the more highly organised plants retaliate upon animals by catching them and absorbing their juices for their own nourishment. [See pages 623 and 624.]

Human Traits in Insect Life. Howbeit, life is not all ferocity. Killing is the universal means of subsistence—the system prescribed for the maintenance of the myriad actors in the pageant; but in tracing upward the development of living creatures from primitive and relatively simple forms one arrives at a point where more amiable traits begin to manifest themselves, ultimately affecting the habits and behaviour of the higher animals as powerfully as the craving for food.

It was said by Linnæus that "Nature is most marvellous in the smallest of her creatures." In no class of animals does one realise the truth of this so forcibly as among the insects. More numerous in their species than all other land animals put together, insects are usually diminutive in size, the largest of them not exceeding the smallest of birds in bulk; yet it is in this group of invertebrate creatures, individually so insignificant, that one first encounters that passionate solicitude for offspring which ranks so high as a virtue in every human code of ethics. Also, leaving man out of account, it is almost exclusively among insects that co-operative communities are to be found, with complete systems of government and subdivision of labour. Many vertebrate animals are gregarious, but these are merely sociable, not social. Some of the hunting creatures may combine for attack, but instances of deliberate co-operation, such as the construction and maintenance by beavers of a dam for the good of the colony, and, by the weaver birds, of a common roof for their crowded nests, are difficult to find.

Social Organisation among Insects. Everybody knows something about the honey bee, and understands something about the perfect manner in which the inhabitants of a hive are divided into classes, each having its structure specialised for definite duties. It is nearly 3000 years since King Solomon urged his readers to consider the ways of the ant; but our knowledge of those ways is still very fragmentary, though the various races of ants have been ingeniously classified, and a full description of their structure, physiology, and nutrition may be found in any handbook. What has been ascertained about their social organisation cannot but stimulate our desire to learn more, for the industry of ants is not only incessant, it is of amazing range and variety, comparable only to the organised activity of a human community.

The ants that keep herds of aphides, tending them with the utmost care, and milking them

THE BIRTH OF THE BEAUTIFUL DRAGON-FLY

A SERIES OF PHOTOGRAPHS SHOWING THE EMERGENCE OF THE DRAGON-FLY FROM ITS NYMPH

In the first of these remarkable photographs we see the nymph crawling along the bottom of the stream. When ready to change into its imago stage this nymph climbs up a stalk into the air and in a few moments there emerges the dragon-fly, which flies off as soon as the sun has dried its gorgeous wings.

From photographs by Mr. J. J. Ward

of that sugary fluid beloved of ants, are more than mere herdsmen or cowboys; they are skilful stock-breeders. Every autumn they carefully collect the eggs of aphides, storing them in the ant-hill through the winter, and when the larvæ are hatched in March they take the little things and place them on the appropriate food-plant, to be milked in due course when they reach the adult stage. Well may Lord Avebury

A MAMMAL THAT HAS TAKEN TO THE AIR—A FALSE VAMPIRE BAT

write of this as "a case of prudence unexampled in the animal kingdom."

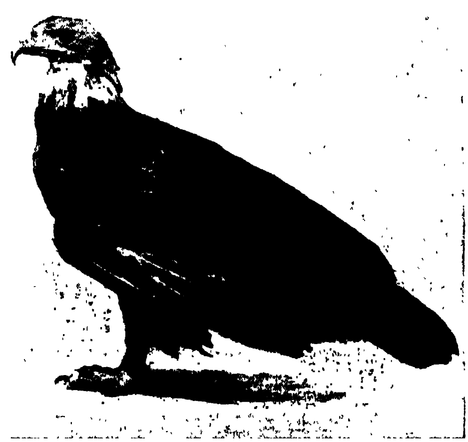
Even more remarkable as an example of foresight, involving a mental process indistinguishable from reason, is the industry of the leaf-cutter ant of Central America. A colony of these, having tunnelled a subterranean passage for many hundreds of feet from the nest to the tree which they have marked out for stripping, send out troops of cutters and carriers, which bring the whole of the leaves into the nest, and hand them over to another set of workers. These chew the leaves into pulp and store it; the mycelium of a certain fungus begins to spread throughout the mass, which they prune carefully to induce it to throw out white nodules, instead of the conidia and spores which would appear if the fungus were left alone. These white nodules form the food of the colony.

Some species, like the European rufescent ant, have given up honest work, if indeed they were ever capable of it, and live by slave-driving, and they have become so dependent on the labour of ant slaves that they cannot even clean and feed themselves, much less construct their own dwellings or rear their young. When deprived of the services of their slaves, these doughty warriors quickly perish of starvation.

A Humble Cannibal. The social ants, bees, and wasps among the Hymenoptera, as well as the termites (so-called white ants) among the Neuroptera, are passive in the care of nurses during their larval and pupal stages; it is strange, therefore, to find that one of the deadliest insect enemies of ants is the larva of a neuropterous fly, the fly itself being perfectly harmless to them. This formidable larva, which is popularly known as the ant lion, marks out with its body a circle in dry sand, within which it digs a pitfall, throwing out the sand by jerking its broad head. It then buries itself at the bottom of the trap and waits until an ant, hurrying along on business intent, trespasses on the shifting slope of the pit. No nightmare can exceed in horror the fate incurred by that hapless insect. The monster, lurking below with wide-set eyes, flings showers of sand upon its victim, till it brings it within reach of its cruel jaws.

It is pleasant to turn from contemplating the murderous proceedings of insects like these to enjoy the beauty of the Lepidoptera—the butterflies and moths—which, if as larvæ they exact a heavy tribute of living vegetable tissue, amply repay the debt in their perfect state by fertilising visits to flowers. No summer day is at its best without the fluttering of their jewelled wings. One might think that such exquisite beauty should be their warrant against persecution. But Nature cannot allow caterpillars to multiply unchecked, wherefore she has provided a special constabulary in the shape of about 6000 species of ichneumon flies, of which some 1200 species are native to Britain. Most kinds of ichneumon flies set about business in a singularly repulsive way. The female thrusts an egg into the body of a caterpillar, cocoon, or chrysalis, whence is hatched a maggot that gradually eats up the tissues of its host, turns into a pupa, and finally issues as a slender hymenopterous fly.

Insects, in the opinion of Mr. David Sharp, must be regarded as the most successful of all



THE WHITE-HEADED SEA-EAGLE

the forms of terrestrial life, but very few of them find water a congenial home. It is true that very many flying insects pass their larval stages in shallow, fresh water; and the metamorphosis from a water-breathing larva to an air-breathing insect is one of the most remarkable processes in Nature, being instantaneous.

First Signs of the Vertebral Column. Of all the myriad forms of life with which the ocean swarms, only very few kinds of insects succeeded in establishing themselves therein; but their absence is amply balanced by innumerable species of crustaceans, some of which people the waters of Polar seas as densely as swarms of locusts do the air. It is in the sea, moreover, that Ascidians, or sea squirts, and their allies abound, presenting the first hint of a backbone in the shape of what is termed a notochord. They appear to be an intermediate form, possibly degenerate, but perhaps only arrested, between the worms, or other type of invertebrate animal, and the vertebrates. One of the most remarkable forms of marine life is the balanoglossus, which studs the sand with worm-like castings. Nothing could be less suggestive of a backboned animal than these slimy creatures which most people would assume to be a kind of marine earthworm. Yet in these Hemichordata, so called because a notochord extends for half their length, must be recognised a direct descendant of extinct ancestors from which all the vertebrates trace their lineage.

The First Vertebrates. Passing them by, we come to the fishes, earliest of all animals to develop a vertebral column, with its indispensable supplement—a skull. No class of living creature is so generally carnivorous as the fishes are. Very few species content themselves with vegetable fare. From the lustrous salmon, ideally modelled for swift energy, to the hideous and sluggish angler or fishing frog, nearly all spend their lives in hunting or being hunted to the death. The blue shark, with its terrible armature of cutting teeth, and the still larger and more formidable Rondeleti's shark, differ from the trout and minnows of the babbling brooks only in the relative size of their victims.

Low as fishes rank in the scale of vertebrates, some exhibit in their habits striking analogies to the inventions of man. Most species take their prey by hunting; others are adept anglers, notably the king of the herrings, or oar-fish, that mysterious denizen of abysmal ocean which there is reason to identify with the sea-serpent. The ventral fins of this great fish, situated close under the throat, are each reduced to a single, long, and flexible ray tipped with an attractive crimson tag, and with these rods and baits Regalecus—to give the creature its scientific name—lures small fry within reach of a pair of serviceable jaws. The angler or fishing frog —the "wide-gab" of Scottish fishermen—buries its huge carcase in the ooze and lies in wait for fishes attracted by the baits displayed on its long dorsal rays. Then there is the archer fish, Toxotes jaculator, of Oriental rivers, which aims jets of water at insects on the bank, or on overhanging foliage, with such true aim as seldom to miss the mark. The invention by man of the electric battery has been anticipated in three genera of fishes—the electric rays in both the Atlantic and Pacific Oceans, the electric catfish of African rivers, and the still more formidable gymnotus of the Orinoco, all of which employ this marvellous force at will, whether in self-defence or for the purpose of disabling or killing their prey.

A COLONY OF BEAVERS ENGAGED IN BUILDING A DAM

Domesticated Fishes. Although the majority of fishes bring the cares of reproduction to a close with the act of spawning, many species have developed traits of higher intelligence by sedulous attention to nest-building, incubation, and attention to the fry when hatched. The pretty little gunnel, or butter-fish, of the British coasts and the common stickleback of brooks and ponds are well-known exponents of domestic virtue, and among exotic fishes may be mentioned the huge Australian barramunda, some of the catfishes, the South African lepidosiren, the North American bowfin, and the fresh-water bass.

The Disappearing Amphibian. From the fishes, or at least from fish-like, water-breathing ancestors with fins and internal gills, were derived in a remote age the amphibians, provided with four limbs and external gills, either temporary or permanent, as well as internal lungs, and these in turn were the progenitors of the reptiles. Both these classes have fallen upon evil times; our globe is no longer the congenial home it was for animals with their special requirements, and their modern representatives have dwindled from their pristine importance. Many races of amphibians have disappeared; those that remain—frogs, toads, newts, and the like—deserve more than passing regard, for among their ancestry of the Carboniferous Age we recognise the earliest appearance on earth of four-footed creatures with five-fingered limbs, a structural design appropriated later for the higher mammals, including man.

The Diminishing Reptile. By imperceptible stages the amphibians pass into the class of reptiles—the only cold-blooded animals breathing by lungs alone. These likewise have been forced by changing terrestrial conditions to surrender the supremacy they enjoyed when the world was still young; for although crocodiles and pythons yet make a respectable appearance in the Eastern hemisphere, and alligators and anacondas retain their places in America, they are all mere dwarfs compared with the ponderous dinosaurs which dominated the Mezozoic land.

The iguanodon of the Wealden Clay was an enormous lizard some thirty or forty feet long, walking on its hind legs in a posture as nearly erect as was consistent with carrying a long and heavy tail clear of the ooze. Fortunately for the prospects of man, iguanodons were starved or frozen to extinction before the freedom of their five-fingered hands could stimulate their brains to a sense of the possible destiny of their race; and nowadays the only existing reptile that is known to resort to biped locomotion is the Australian frilled lizard, a strange little being that tries to frighten away assailants by making hideous grimaces at them.

Conversation Between Animals. Anybody who has closely observed the behaviour of animals among themselves can scarcely doubt that they are able to communicate with each other, if not by uttered sound, then by some other recognised code of intercourse. That human beings are either deaf to their conversation, or, hearing the sound thereof, possess no key to interpret it, proves nothing; for our auditory chamber is sensitive to but a limited range of sound. There are many persons who have never heard so high a note as the squeak of a bat. Depend upon it, the sounds we hear wild animals utter, and many that they utter which we do not hear, are not mere noise; they are charged with significance.

The pageant has not been altogether silent up to this point; crocodiles grunt or bark, frogs croak, many fishes possess and exercise sound-producing organs; but not hitherto has it been enlivened by a single note of music. With the advent of the birds, however, the air soon becomes vocal; not very musical at first, for birds are but modified reptiles, and long ages had to elapse before they could bring themselves to discard teeth.

The Remarkable Advance from Reptile to Bird. Systematists hold that the modification of reptiles into birds bridged a narrower gap than that dividing any other two classes of vertebrate animals; nevertheless, the change from cold-blooded creatures to those which, like birds, have a blood-temperature several degrees higher than that of man is a remarkable one. Certain it is that no class of creatures presents a more varied or more attractive subject for observation than do the birds. No animals exceed some of them in devotion to their young, or exhibit more dauntless courage in defending them. Intrepid human hunters go far afield to match themselves against big game, but where is the sportsman who will venture unarmed to encounter a creature 112 times his own bulk? Yet a cock partridge, which flew at a friend of mine, continued to peck violently at his boot until the mother bird had collected her brood and led them to safety.

The Protective Colouring of Birds. The colouring of birds commands admiration, not only for its range between the sable of the raven and the spotless candour of the swan, with every conceivable combination of iridescent or pigmentary hues, but also for the beauty and structural complexity of the plumage on which it is displayed. One may see yon fellow cleaning out his pipe with the tail-feather of a pigeon or the pen-feather of a gull, without bestowing a thought on the delicate adjustment of interlocking hooks that unite the fibres into a firm, elastic web.

Except among the falcons and hawks, the male usually has the advantage in size and brilliancy of plumage. The office of incubation being generally discharged by the female, it is important for her safety that her colouring should assimilate to her immediate environment. So closely do these correspond that it is commonly the bright eye of a sitting grouse, partridge, or ptarmigan that betrays the nest to a passer-by. In some families, however, the male bird takes exclusive charge of the nursery, and dresses for the part. Thus in the Eclectus genus of parrots, inhabiting the Moluccas and the Solomon Archipelago, the females are usually attired in gorgeous scarlet. They lay their eggs, and, leaving their mates to hatch them, fly away to disport themselves in their fine raiment. The dutiful husbands, on the other hand, wear protective green plumage, nicely matching the foliage round the nest. It may further be mentioned that in this genus the disparity of the sexes is so extraordinary that they were at first classed as belonging to separate species.

Mammals—the Highest Vertebrates. We have loitered so long on the upward course of our pageant as to leave little time for noticing the highest group of vertebrate animals—

namely, mammals, or creatures which suckle their young through teats, or exceptionally, as in that strange egg-laying mammal the duck-billed platypus, which nourish their young in a mammary pouch. The link connecting mammals with the reptilian vertebrates still awaits elucidation, although Professor Seeley has shown how closely the dentition of the fossil Theriodonts, an extinct group of large reptiles, approaches the characteristic specialisation of mammalian teeth.

In proportion as living organisms rise in the scale of being do they part with their plasticity, yet no class of animal has shown greater adaptability to environment than has the mammalian. Every acre of land capable of yielding vegetable food, and thousands of square miles, especially in Polar regions, which yield none, have been peopled by warm-blooded, more or less hairy, quadrupeds; although man, the highest mammal, has exterminated some species and greatly reduced the multitude of others.

Mammals that are Driven to the Air and Ocean. So rapidly did mammals increase, when they obtained a footing on the earth, that the land proved incapable of sustaining them all. A branch of the Insectivora—that great order of which the hedgehog, the mole, and the shrew-mouse are British representatives—being in danger of being crowded out, took to themselves wings and founded a new order—Chiroptera, or bats—which subsist by aerial hunting. The ocean would seem a most unsuitable home for creatures unable to inhale the free oxygen in water, yet it once swarmed with enormous mammals—whales, walrus, dolphins, porpoises, seals; and even now, after men have been working destruction for centuries upon these marine herds, there still roams in the sea the most gigantic of living animals—Sibbald's rorqual, or blue whale, attaining a length of upwards of 85 feet. Larger creatures than this have trod the earth in the past—diplodocus Carnegii, for instance, which, from nose to tail-tip, measured 120 feet—but none has ever equalled the rorqual in bulk.

By a remarkable coincidence, the two creatures which were the last to own the supremacy of man are respectively the largest and well-nigh the smallest that have come under his dominion—namely, Sibbald's rorqual and the pestiferous mosquito. The rorqual was the only animal in the world which no man, not even the most intrepid whaler from Dundee or Bergen, dared to attack, until the invention a few years ago of bomb-harpoons fired from a gun. But now this giant of the deep is hunted as diligently as any other whale, and its extinction may not be far off, for whales reproduce themselves very slowly. The mighty rorqual never did injury to the human race; the slenderest antelope could not be more innocent of offence; but the other creature which set man longest at defiance—the malarial mosquito—is accountable for more human mortality and suffering than all the beasts of prey that ever roamed the world, but is now being ruthlessly stamped out.

By these crowning examples of the supremacy of mind over matter, the ascendancy of man over his fellow-denizens of the globe has been raised to the highest pitch hitherto attained, and with them the pageant of life, as now revealed to us, may be brought to a fitting close.

HERBERT MAXWELL

AN EIGHTY-FOOT SIBBALD'S RORQUAL, OR BLUE WHALE, THE LARGEST EXISTING MAMMAL

Principles of the Transformer. Ratio of Transformation. Magnetising Currents. Types of Transformer. Insulation. Ventilation.

THE TRANSFORMER

Alternating Currents can be Transformed. Among the properties of alternating currents is the facility with which they can be transformed from one voltage to another. Currents generated or transmitted at a high voltage can be transformed down to a low voltage, or those generated at a low voltage can be readily transformed up to a high voltage; and all this without having recourse to any revolving machinery, provided the currents are themselves of the alternating kind. Currents of the continuous kind cannot be so transformed without the employment of revolving machinery with commutators. The stationary apparatus for transforming alternating currents is termed a *transformer.*

Energy Relations in Transformation. It was pointed out, in page 232, that the *power* of any electric current is always the product of two factors, the volts and the amperes, and the product of the volts and amperes was called the number of *watts*, 1,000 watts being called one *kilowatt.* Now, in any transformation it is impossible to get more power out of the apparatus than is put into it; in fact, as there is always a slight loss due to resistance, etc., the efficiency of even the best transforming apparatus is less than 100 per cent.

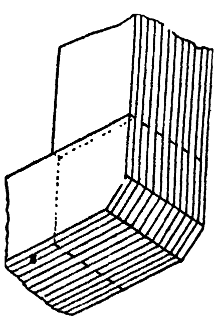
In an electric transformer power is put into the apparatus at one side—called the *primary* side—and an equal amount (save for the small percentage of loss) is taken out at the *secondary* side. Suppose a case where, at the primary side, 20 amperes are being supplied at 1,000 volts; then, supposing that the volts and amperes are in phase [see page 1289] with one another, there is power going in at the rate of $20 \times 1{,}000 = 20{,}000$ watts, or 20 kilowatts.

On the secondary side, the power given out will be practically the same—that is to say, the product of the secondary amperes and volts will be just a little less than 20,000 watts. Suppose that the transformer is designed (we shall see presently how this is done) to give out its currents on the secondary side at the low pressure of 50 volts, how many amperes will there be? Clearly, if the product is to be a little less than 20,000 and one of the two factors is 50, the other factor—the amperes—will be a little less than 400. In fact, if the transformer has an efficiency of $98\frac{1}{2}$ per cent., the secondary output will be 394 amperes. Or, putting it the other way round, if we want to get out 400 amperes at 50 volts, the current we shall have to put in at the primary side at 1,000 volts will be just a little more than 20 amperes—namely, 20·3 amperes, the extra 0·3 ampere being the amount to make up a $1\frac{1}{2}$ per cent. loss.

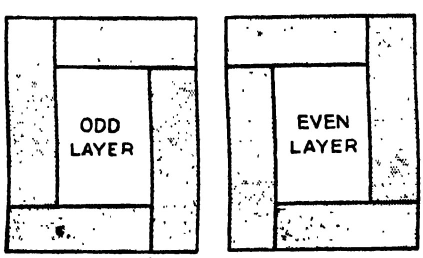
Ratio of Transformation. We see, then, that we can get out at one side of a transformer more current than we put in at the other, provided we arrange to take it out at a lowered pressure. This is just as truly in accordance with first principles as is the action of a lever. A man by pressing on the long end of a pivoted lever can exert ten times as great a force at the other end, provided the fulcrum is so arranged that while he moves his hand downwards through an inch the load at the other end is raised only $\frac{1}{10}$ in. In a lever, whatever is gained in force is lost proportionally in range, and so the energy given out at one end is equal —save for a small friction loss—to the energy that is put in at the other.

So in the electric transformer, whatever the proportion between the two voltages, that between the amperages is practically the inverse. The ratio between the two voltages is called the *ratio of transformation.* In the above example, where the primary voltage was 1,000 and the secondary voltage was 50, the ratio of transformation was 1 : 20; and the ratio of the currents was practically 20 : 1—that is, 400 secondary amperes to 20 primary amperes.

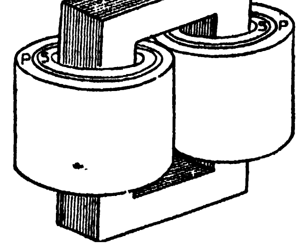
Principle of the Transformer. Like the dynamo and the motor, the alternating-current



108. CORE-JOINT



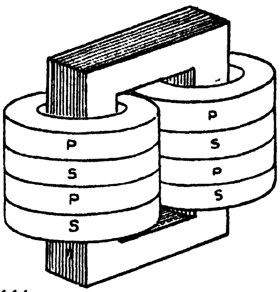
109. ARRANGEMENTS OF STAMPINGS IN SHELL TYPE FOR OVERLAPPING



110. CORE-TYPE TRANSFORMER CONCENTRIC COILS

transformer has developed from Faraday's classical apparatus. In fact, in its elementary form, as an iron ring interlinking itself with two copper wire coils (the original form constructed by Faraday), it has been already described and depicted [see **43**, page 888].

Referring back to **43**, the ring, with its two independent insulated coils A and B, let us consider what happens in it when the primary coil A, instead of receiving an interrupted battery current, receives an *alternating current*, such as was described in the chapter on the *alternator* [page 1284]. The alternating current, flowing round the coil A, will obviously create in the iron core an alternating magnetic flux. That is, there will be set up in the iron ring a magnetic flux, the path of which is a closed path within the iron of the ring ; and this flux will increase in value to a maximum, will then die away, will reverse in direction, and grow to a negative maximum, and will again die away, repeating this cycle of operations exactly as often as the current that produces it goes through its round of operations. If the primary current has a frequency of 50 cycles per second, the alternating flux will alternate with the same frequency.



111. CORE TYPE TRANSFORMER SANDWICHED COILS

Now this alternating flux interlinks itself with the secondary circuit B, and will therefore by its variations induce in the windings of that coil an electromotive force proportional to the intensity of the magnetic changes, and therefore also of the same frequency as the magnetism.

We see, then, that by means of a purely *magnetic mechanism—viz.*, interlinkage with the magnetic lines of an iron core—the alternating voltage which is applied to the terminals of the primary coil A is reproduced automatically as another alternating voltage at the terminals of the secondary coil B ; and yet there is *never any electrical connection* whatever between the two windings.

Automatic Operation of Transformer. The transformer is automatic in another sense also. Even if the secondary circuit be left open, so that no current flows in it, there will be a voltage induced in it by the alternating flux interlinked with it. When the secondary coil is thus on open circuit, the current that flows into the primary coil from the alternating mains will be merely a magnetising current, of small amount, and will be practically a wattless current [page 1290], as the amount of energy lost in magnetising is trifling. What, then, will happen if the secondary circuit be closed through a resistance ? In that case there will be a secondary current, and it will give out power and heat the resistance through which it flows. This power must come from somewhere, and the only way from which it can come is through the primary circuit by more current flowing in from the mains. If this were not so, we should have—what is impossible—a creation of energy out of nothing. So as we draw current from the secondary side, and the more we draw, so, automatically, does more and more current flow into the primary side from the mains.

Magnetising Current. As the whole operation of the transformer depends on the magnetism of the iron core, which, with its alternating flux induces the voltage in the secondary, it is clear that even when no current is being drawn from the secondary, a current must still flow in from the primary mains to keep the secondary circuit "alive." This magnetising current at no-load will, however, be a relatively small current, because, as the iron core is constructed as a closed circuit without gaps, a comparatively few ampere-turns will suffice to create the magnetic flux. Thus, for example, a 20-kilowatt transformer, which, when supplied from mains at 1,000 volts, took at full load a current of 20·3 amperes, was found at no-load to take the insignificant magnetising current of 0·28 amperes.

Ratio of Windings. We have seen that transformers work with some definite ratio between the primary voltage of the supply mains and the secondary voltage at which they give out their current, and that this ratio was called the ratio of transformation. Now, this ratio has nothing to do with the size of the transformer, but depends only on the relative numbers of turns in the two windings on the core. It is, in brief, the same as the ratio of the windings. If we require a transformer to transform down the voltage from, say, 1,000 volts on the primary side to 50 volts on the secondary side—that is, in the proportion of 20 to 1—then the number of turns in the primary winding must be 20 times as great as the number of turns in the secondary winding. For a step-down transformer the primary will have more turns than the secondary. For a step-up transformer the secondary will require more turns than the primary.

We see this rule even in the case of the induction coils used for procuring spark discharges. The primary source is a battery of a few volts, while to produce a spark in the secondary circuit needs the generation of thousands of volts. Hence, the primary winding consists of one layer only of thick wire, while the secondary winding consists of a very fine wire with hundreds of thousands of turns.

If a transformer were made with an equal number of turns in its two coils, it would transform neither up nor down : the secondary voltage would be the same as the primary voltage, and the ratio of transformation would be 1 to 1.

The rule for transformation ratio may be stated in symbols. If S_1 be the number of spirals or turns in the primary winding, and S_2 the number of turns in the secondary

winding, E_1 the voltage induced in the primary (practically equal to the applied primary voltage of [illegible] dary voltage, then the proportion that exists is simply:

$$\frac{E_2}{E_1} = \frac{S_2}{S_1};$$

and as the currents are inversely proportional to the voltages, it follows that the primary and secondary currents C_1 and C_2 (or as sometimes written I_1 and I_2) will be connected by the rule

$$\frac{C_1}{C_2} = \frac{S_2}{S_1}.$$

As a matter of fact, the actual primary current will, as already indicated, be always slightly greater than the value of C_1, as calculated by this rule, because allowance must always be made for the existence of the magnetising current.

Magnetising Ampere-Turns Needed. Attention was drawn on page 1012 to the conception of the magnetic circuit, and an example was there given of the way of calculating how many ampere-turns are needed to excite the required magnetism in a given case. Now, the case of transformers is even simpler, because in its magnetic circuit there are no gaps and the cross-section of iron in its core is uniform throughout. Experience shows that it was not wise (if waste of energy in the iron is to be avoided) to force the flux-density in the cores of transformers beyond a moderate value. As an average figure, therefore, a flux density of 35,000 magnetic lines per square inch may be assumed.

112. WESTINGHOUSE TYPE OF TRANSFORMER

Now, taking good sheet iron or mild steel, such as is used in building the cores of transformers, we may say that experience shows that this flux-density will be attained if we provide an excitation of three ampere-turns per inch length of core. Suppose that the core of our transformer had a mean length of 60 inches along the magnetic path, then an excitation of 180 ampere-turns would be about right for it. And if the primary coil had, for example, 1500 turns, then the magnetising current (at no-load) would be $180 \div 1500 = 0{\cdot}12$ amperes. We have given three ampere-turns per inch as an average figure. A more accurate estimate can be got by the following rule, The ampere-turns per inch that are needed will be

$$1{\cdot}2 + (\mathbf{B} \div 14000),$$

where **B** stands for the number of lines per square inch of flux-density. The best kinds of transformer iron—for example, the British quality known as Sankey's "stalloy"—will require even fewer ampere-turns per inch than this.

Joints in the Magnetic Circuit. To keep down the magnetising current to a low value, as is necessary if the transformer is to be of high efficiency, not only must the iron be of good quality, but all joints and gaps in the circuit must be avoided, because more ampere-turns are needed (as explained on page 1012), to drive the magnetic lines across air than to drive them through iron. Hence, in the construction of transformer cores it is usual to obviate all joints by interleaving the iron plates by making them overlap at the corners, as shown in **108**.

Forms of Transformers. The practical transformer of today differs in many respects from the primitive ring of Faraday. The core is not solid, and is not ring-shaped. If it were solid it would grow hot by reason of parasitic eddy-currents induced in the cross-section of the iron, and these currents would waste some of the energy. If it were ring-shaped the coils would have to be threaded on by hand, and not wound on a lathe. So, instead, the cores are built up of strips of sheet iron or mild steel about 13 or 14 mils thick (that is, from 0·013 to 0·014 inch). Fig. **109** shows a very usual shape of core built up of strips of sheet iron which are assembled so as to overlap alternately at their corners. To insulate the strips lightly from one another it is usual to paste a thin layer of paper on one side of each strip. The coils are wound on bobbins or formers; and it is easy with this construction to slip the coils upon the two vertical limbs when the core has been partially built up.

Again, reference to Faraday's ring (**43**, on page 888) will show that in this primitive form the primary coils A were all wound on one side, and the secondary coils B on the other side of the core. But it is found that this arrangement is not satisfactory if the transformer is to give good voltage regulation, as it leads to leakage of magnetic lines between the two windings. It is necessary to keep the two sets of windings as near together as possible, in order that as far as possible *all* the magnetic lines generated by the coils A may thread themselves through the coil B, and *vice versâ*. So, therefore, it is usual to put half of the A coils on each limb, and half of the B coils on each limb. This is done either by arranging them concentrically, as in **110**, or else by winding them in sections, and then sandwiching the sections of the A coils between those of the B coils, as in **111**. Fig. **112** shows a type which is made by the Westinghouse Company, and has come into extensive and successful use.

Shell Type. As the essential thing in a transformer is that the two coils shall both surround a common core of iron, there are many possible types of construction. The rectangular form described above is commonly spoken of as the *core type*; but there is another frequent form,

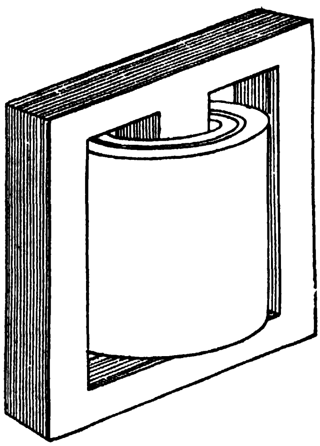
known as the *shell type*, in which a large portion of the iron is outside the copper coils. Figs. **113** and **114** belong to the shell type. The laminations appropriate to the former figure are rectangular, with two openings, as in **115**, to admit of the coils, the laminations being themselves built up of strips or sheet stampings which admit of their being put together around the coils. A more recent form is that of Berry, depicted in **116**, in which the coils are cylindrical and concentric, with the cores built up of strips of iron of several widths, in bundles, affording ventilating channels in the interspaces and requiring a minimum section of iron.

Insulation of Transformers. Inasmuch as one side of a transformer is invariably at a high voltage, the question of insulating the coils must be very carefully attended to, especially as, in order to get a good voltage regulation, the primary and secondary coils are sandwiched, thus further increasing the proximity between the two sets of coils. Each maker has his own rules in the matter of insulation, but the general practice may be stated as follows. For coils in which wire is used, the wire is doubly and often trebly covered with cotton and varnished with a good, hard-drying varnish once or twice after it is wound. For coils wound with strips, the strips may be wrapped with cotton tape or even manila paper if the coils are circular, and the whole is dipped in varnish and dried as before.

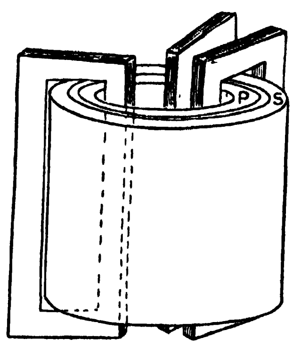
Before being placed on the limbs of the transformer, each coil is separately taped with cotton impregnated with bitumen or rubber, in order to insulate the coil as a whole from its neighbour. In cases of extra high voltages, this last is insufficient, and micanite rings and bushes are inserted between the coils, or they are held mechanically apart to a distance of, say, one-eighth or three-sixteenths of an inch by ebonite or hard fibre distance-pieces. The leads which bring the primary currents to and from the coils should be extra heavily insulated, and the supports for the terminals should be of a very substantial character.

Heating of Transformers and other Electrical Apparatus. On seeing any piece of electrical apparatus, we are inclined to ask: "How are we to know the limit to its capacity for transforming electrical to mechanical energy, or electrical energy to electrical energy at a different voltage, as the case may be?" Now, in all apparatus used for converting energy a certain loss of useful energy results. This energy appears in the form of heat, and in electrical apparatus the capacity for transformation is limited by the maximum temperature to which we may allow the apparatus to be raised by this spontaneous liberation of heat. The loss of energy in electrical apparatus may be divided under two heads—namely, that in the copper conductors which carry the electricity and that in the iron core which carries the magnetism. The first of these losses may be estimated from the rules already given in the chapters beginning on pages 229 and 635, and the second has been commented on in the present chapter.

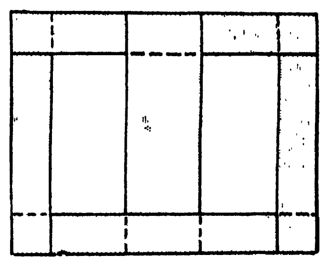
The further point, however, for us to notice here is that the copper loss is going on only when the apparatus is loaded, and that its value depends upon the value of the load, while the iron loss is taking place all the time the apparatus is at work, whether it is loaded or not—that is, all the while it is "alive," and is therefore independent of the nature of the load.



113. SIMPLE SHELL TYPE TRANSFORMER



114. SKELETON DIAGRAM OF BERRY TRANSFORMER



115. ARRANGEMENT OF STAMPINGS IN SHELL TYPE FOR OVERLAPPING

In transformers the proportioning of these losses requires great consideration, for we have the iron losses going on night and day, because the mains must be kept alive, while the copper losses only occur for a few hours in the evening, while the load is on. The question of reducing the losses which are constantly taking place in large systems of high-pressure alternating current distribution has received a great deal of attention, and both the Berry and the Westinghouse Companies have developed switching arrangements whereby it is possible to use a small transformer in connection with a much larger one. At periods of light load the small transformer, with its small losses, supplies the energy, the large transformer being cut out of circuit. When the demand becomes too great for the small transformer, the larger one is automatically switched into circuit again. In this way the losses can be very materially reduced.

In order to increase the capacity of a piece of apparatus of given size, two things are possible—

namely, to reduce the losses which take place and to ventilate it more thoroughly, so that the heat is carried away more quickly.

Ventilation of Transformers. We have seen the provisions made for ventilating dynamos, how the armature is built up with spaces to allow a circulation of air through the inmost parts of the machine. With transformers this question is of greater importance. In small sizes, it is sufficient to allow the surrounding air to cool them if ample provision has been made for its free access among the coils and core by suitable spacings. Fig. 117 shows a typical section of a transformer core and the arrangements for circulation of the air between the straight line outline of the core and the inside of the circular core. With large sizes, however, these arrangements are not sufficient, and it becomes necessary to cool the coils artificially.

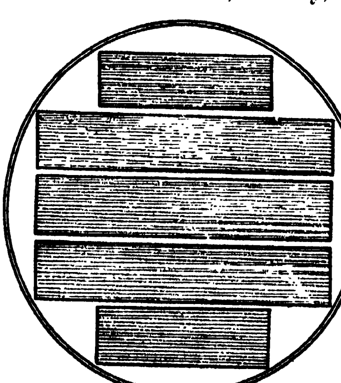
116. BERRY'S TRANSFORMER

For this there are two methods at present in vogue. In both of these the transformer is erected in a closed case, and in the first, dry air, free from dust, is blown by fans through the apparatus; while in the second method the case is filled with a suitable oil which enters into all the corners and nooks, and, by its automatic circulation when heated by the waste energy, conducts the heat to the case, from the large exposed surface of which it is more easily radiated. In very large sizes even this is not sufficient, and the oil is cooled by leading through it pipes through which cold water is made to circulate.

The Design of Transformers. There are two main features of a transformer which we may vary, and these are the core and the coils. We may have a large core and only a few turns of wire around it, or *vice versâ*.

Practice in transformer design has, however, now settled down, and the happy medium which has been evolved between these two factors is now well understood. The size of core may be represented by N, the total flux it has to carry and the size of coil by the ampere-turns at full load, written C_1S_1 or C_2S_2.

Now the ratio for these two quantities, that is, $\frac{N}{C_1S_1}$ is known as the *flux factor* (Y), and for ordinary small size transformers (*core type*) cooled natural draught, the flux factor is between and 70. For artificial cooling of transformers, the flux factor is somewhat higher, varying between 90 and 120 as the voltages become bigger.



117. SECTION OF CORE SHOWING PROVISION FOR VENTILATION

The only other formula necessary is that for the electro-motive force, which may be written in the following equation:

$$E_1 = 4{\cdot}4 \times f \times S_1 \times N \div 10^8,$$

for it is now a matter of simple algebra to deduce the actual values of N and C_1S_1 as follows:

$$C_1S_1 = \sqrt{\frac{Kw \times 10^{11}}{4{\cdot}4 \times f \times Y}}$$

and

$$N = \sqrt{\frac{Kw \times 10^{11} \times Y}{4{\cdot}4 \times f}}$$

As an example, take the case of a 100-kw transformer, oil-cooled, transforming from 5000 to 500 volts at 50 cycles per second.

A suitable value of Y, the flux factor, is 90, and so, by the equations given, we have

$$C_1S_1 = \sqrt{\frac{100 \times 10^{11}}{4{\cdot}4 \times 50 \times 90}}$$

22,400, about;

$$\text{and } N = \sqrt{\frac{100 \times 90 \times 10^{11}}{4{\cdot}4 \times 50}}$$

= about 2,000,000 lines.

The rest of the design consists simply of making a core large enough to carry the two million lines and to envelop the coils, which must be of sufficient size to carry the respective currents without overheating.

Autotransformers. Transformers are sometimes used which have only one winding. These are called autotransformers.

If a coil having, say, 40 turns is wound on an iron core, and applied to mains which supply alternating current at a pressure of, say, 200 volts, then, assuming one end of the coil to be at zero, the other end will be at 200 volts. The voltage per turn will therefore be 5 volts. So, if a tapping is taken off at the middle of the coil we can draw current at 100 volts from this point. Or, similarly, from a tapping at 10 turns from the zero end, current can be obtained at 50 volts. The current supplied at any tapping-point will be to the current passing into the transformer inversely as the voltages concerned. Thus, if we take current at 50 volts, from a supply at 200, and the current drawn at 50 volts be, say, 12 amperes, the current that will run into the transformer from the mains will be only 3 amperes. One quarter of the coils in that case will carry 9 amperes, and the other three quarters will carry 3 amperes. Every autotransformer, therefore, must be designed with wires of appropriate thickness to carry the respective currents.

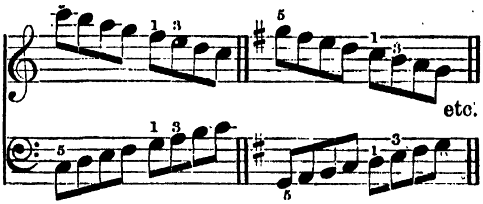
An autotransformer is reversible; that is, it can be used either for stepping down from a high voltage to a lower or from a low voltage to a higher.

SILVANUS P. THOMPSON

Stretching the Hand. Playing with Hand Movement. Arpeggio Playing. Double-note Passages. Weight Touch. Scale Fingering.

SCALE PLAYING

Having become familiar with the scales, taking each hand separately, we must take them next with the hands together in contrary motion, thus:



Passing under Thumb. In learning to play the scale the *reverse way*, ascending with right hand and descending with left, begin by passing the thumb along under the fingers as soon as it is free to leave its key, and so have it "prepared" over the fourth note of the scale. In placing it on F, and the fore-finger on G, there may be a slight—a very slight—

double lateral movement of the wrist. But this must be so *very* slight as not to disturb the general impression of the hand continuing to lie obliquely across the keys. In scale playing there is no stretching of the fingers; slight lateral movements of the wrist and a steady lateral movement of the arm *bring* the fingers over the keys. But in piano playing, nevertheless, stretches of the fingers and hand are sometimes necessary. Here, again, the muscular conditions must, as far as possible, be those of ease—freedom from restraint.

Stretching the Hand. For octaves and tenths, etc., we must let the stretching be gradual and gentle, and so achieve it without rigidity, and be able to retain elasticity of touch. Gentle exercises away from the piano, practising alternate out-stretching of all the fingers, and gentle but complete reclosure of the fist, is good for this and for the general health of the finger and hand muscles. All kinds of easy though full-sweeping gymnastics of the hand and arm are indeed good for the pianist, provided always there is no rigidity.

The general principles of all such gymnastics are these: To use fully one set of muscles, and to follow that up by immediately using the opposite set, taking care, however, never to use the two opposing set of muscles simultaneously. Stretch out the arms and then refold them, stretching them at all kinds of different angles and altitudes in their relation to the body; let all the motions be full—go as far as may be in either direction, but always *gently*. Remember to use such gymnastics *after*, never *immediately before*, playing.

Octave playing brings us to hand movement—*i.e.*, playing without any movement of the fingers relatively to the hand, but with movement of the whole hand instead, relatively to the fore-arm.

Playing with Hand Movement. This was, till recently, termed "wrist action." This downward movement of hand at knuckle end—hand touch—"need not exceed the distance from key-surface to key-bottom"; but if, as in the case of finger movement, we play (in slow time) with a preliminary lifting of the hand, this must be followed by its *falling* on the keys, thus relaxing the up muscles and making key-contact without any hitting. In the latter case, we must be careful never to *think* the lifting of the hand, but always to "*think* key-movement" instead. For if we attend to this upward movement of the hand, which is not essential to tone production, but is merely a form of muscular gymnastics for the freeing of the muscles, we may overlook the *essential*, that feeling of the resistance of the keys before and as we move them into sound, which is the *only* way of making sure that we get what we want from them.

Our attention must always be given to the making of *sound* "by using our sense of key-resistance, and by listening for the beginning of the sound." In playing repeated notes thus:

we must bear in mind that the sound is reached before the bottom of the key-bed is reached, and that in good pianos with repetition action it is even not necessary in very soft passages to let the key rise to its highest level between the repetitions, and that these, therefore, can be performed with a very slight up and down swaying of the key.

Position of Fingers and Wrist in Hand-touch. Now note in connection with hand-touch, or so-called wrist-touch, that: (*a*) "The fingers do not move relatively to the hand. Fingers should not move during key descent, except in finger-touch. (*b*) The normal height of wrist is about level with knuckles or slightly lower. This may vary, but rapid octaves are found, as a rule, easier with the wrist-level slightly higher than the normal. (*c*) The wrist must alternately rise and fall, slightly, when a passage requires the thumb on alternate black and white keys; wrist lower for black than for white keys, movement not greater than will suffice to keep elbow quiet." [Matthay.]

Arpeggio Playing. Arpeggio playing now calls for attention. Arpeggi are the notes of chords played in succession; thus in the chord of C:

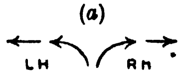
and in extended arpeggio passages the thumb, as in scales, passes, and is passed by, the fingers. The hand, in such passages, must lie still more obliquely to the keys than in scale playing. Extended arpeggi, in short, are just big-striding scales, and the scale habits here call for slight exaggeration. "The arpeggio," says Matthay, "in addition to the normally outwardly-turned position of wrist (as in the scale), requires slight lateral movements of the hand and wrist to enhance the lateral stretch of the thumb and fingers."

Well oil your wrist, so to speak, by omitting all contrary exertions, and *gently* rest on the connecting note. Preserve the oblique line of hand to keys even to the extreme ends of keyboard, following the hand up with a lateral movement of the arm.

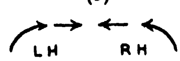
The oblique position of hands for single-note scales and arpeggi is, as we have seen, one that causes a slight turning in of the hands towards the body.

Double-note Passages. For double-note passages, on the other hand, it takes the form of (*a*), from the centre of keyboard outwards, and this other form (*b*) from extremes of keyboard towards the centre. In short, in such passages the hand is turned in the direction the scale is travelling. All such laterally modified positions of the hand must be assumed and retained with the greatest possible ease—*i.e.*, without any stiffness induced by the interference of the contrary muscles. In playing double-note passages *legato*, the connection can only be maintained at the cross-over junction by *one* of the two notes. Realise this, and rest gently on this one note with fifth finger or thumb while taking up the new position for the next two. And remember to leave the fifth finger bendable, as learned in the Daily Test.

(*a*)



(*b*)



The Three Movements. We have spoken of finger-*movement* (the only movement available for a real *legato*), hand-movement, used for rapid double-octave and sixth passages, etc. Besides these we also require arm-movement, the movement we use to carry the hand and fingers to the keyboard at the beginning and end of phrases, and also for slow successions of chords and single notes. In approaching the keyboard, let the arm gently fall of its own weight, but not necessarily of its *whole* weight. Single detached notes are mostly played by the arm.

So-called "portamento" passages, indicated by a combined use of the staccato dot and the legato slur, thus ⌣ which we find frequently in Chopin's music, for instance, and which are really a duration emphasis, are played invariably by arm-weight and frequently by arm-movement.

Muscular Combinations. We have seen that the weight of the arm and the exertion of finger or hand, or both, are the muscular agencies we use against the key to move it. These are our artist's colours—our palette. From these, and from combinations of these, we get all our effects. Thus, if in finger-movement we eliminate both arm-weight and hand-exertion, we get light, prestissimo passage playing. If we add hand to finger exertion, during finger-movement, we get a more robust tone and less speed. If we add arm-weight to finger and hand exertion, during finger-movement, we get any range of tone the instrument can yield, but no more than a limited degree of speed. The same thing applies to hand-movement. With it, when we wish speed rather than tone amount, we eliminate arm-weight, and so on. Such combinations do not affect agility and tone amount only; they must also be most carefully chosen, that we may obtain the desired tone *qualities*. When muscular exertion takes the lead and calls on arm-weight to follow, the tone is bright and rousing.

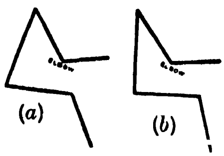
Weight Touch. When arm-weight, on the other hand, lazily tends to fall, and is, as it were, tardily conveyed to the keys by the muscular exertion, then the tone, thus more gradually induced, has a character which betrays its origin and affects us with its inherent quality, persuasive, insinuating, stealing upon one's senses unawares. If we want to soothe our audiences with a nocturne, we can only do so by relaxing our own arm-muscles and using just as much exertion of finger and hand as will convey the impetus of this tone-inducing weight to the hammer and to the string through the keys; and the bent and flat finger attitudes respectively help greatly to increase this difference in quality. The manner of tone production just described, Matthay has termed weight touch, to distinguish it from all other kinds which are started by muscular exertion. These muscular combinations are the most important of all the Matthay teachings, further details of which may be found in his own works.

Bent and Flat Finger Staccato. These different qualities of tone are equally available in staccato and in legato. When the "bent" and "flat" finger attitudes are employed for *staccato*, they show two different kinds of rebounding. The "bent" movement of the finger rebounds to the position it held before key-movement. The "flat" *continues* in the direction in which it is going, as though very quickly sliding a threepenny-piece from the keys.

Arm Position. We have spoken of the normal attitude and varying position of fingers and hands and wrists. What is the normal position of the arm? A rather

outstretched one, not a right, but rather an obtuse angle. Not thus,  , but rather thus,  . The forearm should either be level from elbow to wrist or else dropping a little towards elbow, thus:   The elbow should hang quite free from the body and travel freely outwards (sideways) when a passage moves to the keyboard extremes.

Do not sit too near the instrument. Sit so that the arm at the elbow "is sufficiently forward of the body," and get this either as in diagram (*a*) or (*b*). If bending slightly forward, support the body well by the waist-muscles at your back, and in any case breathe fully and deeply.



Mastery of Keyboard. We have treated of the several laterally modified positions of the hand that must be assumed and retained with the greatest possible ease. Now, it is evident, as music is not made up of continuous series of scales or arpeggio, or five-finger position groups or repeated notes, or of octaves or of chords, but of endlessly varied combinations of such, that the hand must be continually varying its position laterally to the keyboard and to the forearm, and that an "oily" adaptability in this respect is indispensable for successful keyboard manipulation. *And through all these changes the hand must lie on the keyboard, hanging from your forearm, and the fingers must thus rest on the keys.* When we have tested for right muscular conditions, we must forget ourselves and our muscles, and give all our attention to the instrument and the music we wish to draw from it.

Technical Material. The material for the study of all these forms of mental muscular instrumental expertness may be found in any piece we practise, all the difficult passages being extracted and used as the stuff of such technics. But ample specialised material is to be found also in Schmitt's "Five Finger Exercises," Beringer's "Daily Practice," Camille Stamaty's "Le Rhythm des Doigts," Germer's "Technics," Czerny's "Virtuosen Schule," and the like, to which the student may refer if he will. We must never begin the muscular practice of such things until the mind has mastered the material, its musical shape, and keyboard contour. Theoretical study, the study of harmony, of chords, passing notes, of form, etc., are necessary for this, as without such study the mind has to burden itself with too much detail.

But besides such scrappy technics as have been alluded to, it is well to work at some larger forms, so-called Studies, in which the constant repetition of some technical difficulty given in a particular figure is made pleasing and musical by the form in which it is presented. Such are helpful in the matter of endurance. For the study of finger facility, nothing better, probably, will ever be written than Czerny's Etudes, which are calculated to prevent the formation of such bad habits, such hindrances to good results of any kind, as *key-bed squeezing* and the use of *down-arm force.* As agility passages can only be played successfully when there is no "jamming" of the key upon the bottom of the key-bed, such studies, properly practised, and the study of staccato, form the best tests and preventatives against such harmful and unnecessary attempts to push the piano through the floor.

In Czerny we find an abundance of delightful running passages with staccato single notes or chord accompaniments, and with every now and then detached *ff* chords on which to try the full weight of our suddenly released arm. For, of course, during all these dainty running passages we have been supporting the weight of the arms with their own "up" muscles; and not only is it delightful now and then to be allowed to relax thus for a moment, but it is essential for us as artists to understand and swiftly bring about such successions of totally opposite muscular conditions as produce such totally opposite instrumental results. Light agility passages also, needless to say, strengthen the arms, since they give them so much work in keeping their own weight off the keyboard. Czerny's "Velocity Studies," "Staccato and Legato," and "Finger-fertigkeit" can be recommended.

Fingering. And now as to fingering. This must be derived not merely from the contiguity of the notes, but also and chiefly from the meaning of the music—its phrasing. Still, there are general rules of fingering which we must make into habits—rules which are broken whenever the phrasing demands it. These rules are: (i) Contiguous fingers on contiguous ivories. (ii) When ebonies are mixed with ivories it is easier, as a rule, and therefore advisable, to leave the black keys to the four fingers, and to use thumb on white keys by preference. Many modern advanced players, *for the sake of practice,* take all the five-finger exercises and scales in all keys with the same fingering, using thumb on black keys and white alike. (iii) Groups larger than five contiguous keys are reached in different ways, thus: (*a*) by extension, (*b*) by contraction. Or (iv) we get along the keyboard by connecting such fingering group units by passing the thumb under fingers or fingers over thumb. The thumb, which was in former times entirely neglected, is used as a pivot for fresh finger-groups, and connects them by passing under the other four fingers, or letting them swing over it as it gently rests on its key. We shall notice now that all scales consist of two such united finger-groups, these two sufficing for each octave.

Scale Fingering. Normal scale fingering we have already learnt. All the major scales with sharps are fingered like the scale of C, with the exception of those scales that make use of all five black keys; the latter are B, F♯ and C♯. These "all-black" keys make use of only two white keys. The thumb is used twice in each octave—we must use it on the two white keys—and this settles for us the position of the two finger-groups. The black keys are grouped

in | | and | | |. Be prepared to use over them either two fingers or three, thus: | | (3 2) or | | | (4 3 2). The flat scales in right hand are fingered with thumbs falling always on the white C's and F's. In the left hand the fingering of flat scales is easy. Till you reach the all-black key G♭, they all begin with the middle finger, and turn the fourth finger over the thumb to the new flat (the flat just added for this particular scale). The old-fashioned fingering of F left hand was 5 4 3 2 1 3 2 1, but it is now permitted to finger this *regularly—i.e.*, like the other flat scales, thus: 3 2 1 4 3 2 1.

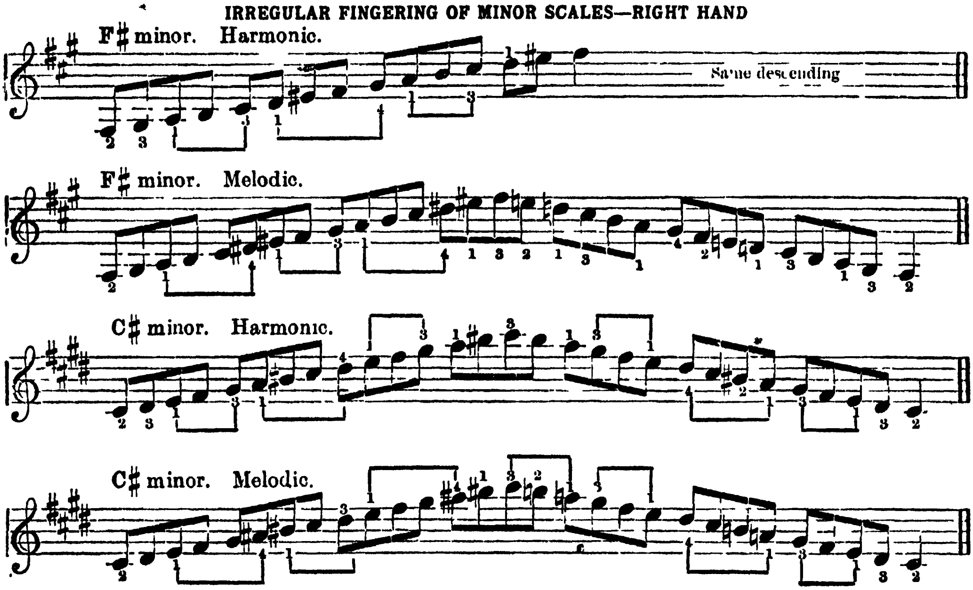
The tonic minors of sharp-scales are fingered like the majors, with the following exceptions: In the right hand F♯ and C♯ minor harmonic and melodic; in the left hand A♭ minor melodic and E♭ minor harmonic and melodic. The fingering of these is given below.

General Principles of Scale Fingering. The only way really to grasp the general principles of scale fingering is to notice that (*a*) there are seven notes to the scale and that we have four available fingers, the fifth being used only at a terminal or at a returning point; (*b*) that we cover the seven notes with these two finger groups 1 2 3 4 1 2 3—that the fourth is used only once in each octave, except when used as a terminal finger, thus:

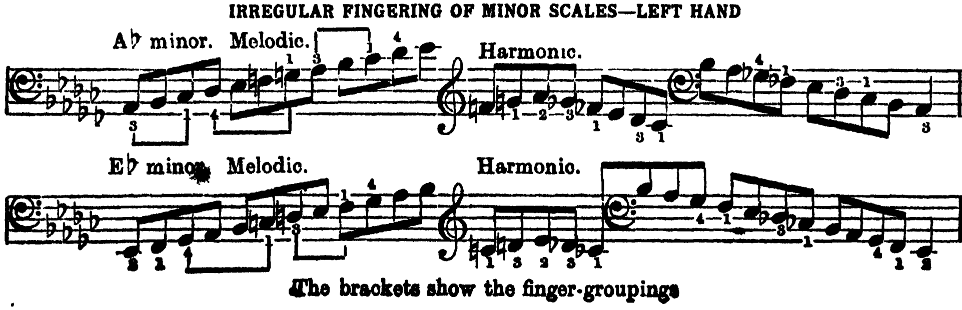
and (*c*) that the arrangement of these finger-groups (the notes on which these two groups shall be placed) depends primarily on our habit of using the thumb on the ivories rather than on the ebonies, and arranging the "turn over" of the fingers over the thumb to occur *to* a black key.

M. KENNEDY FRASER

IRREGULAR FINGERING OF MINOR SCALES—RIGHT HAND



IRREGULAR FINGERING OF MINOR SCALES—LEFT HAND



The brackets show the finger-groupings

A Survey of the Many Inventions Embodied in Modern Textile Machinery

THE FIRST TEXTILE MACHINES

THE best introduction to the mechanical side of textile industry lies in a short consideration of the methods used in manufacturing before machinery was adopted about 150 years ago. The machine makers have improved upon the results of manual labour, and have enormously increased the output of the worker, although whole sequences of intricate machines have to be employed to do what was formerly done simply by changing the action of the hands. Machinery has made textile processes more confusing to learners and outsiders, but the problems and the principles are the same, whether manual effort or machinery is used in performing them.

A mass of raw material has to be converted into fine and uniform threads, and the threads have to be crossed and interlaced to form cloth. The operation begins with the reduction of the material to a clean state by the removal of foreign matter and of undesirable fibres, sometimes followed by the blending of fibres of different qualities. Some of these processes, like the sorting of wool, have still to be done by hand; but only the peasant manufacturers of the Hebrides and of the remoter parts of Ireland now scour their wool by treating a few pounds at a time in cooking-pots. Machines have replaced the willow wands with which cotton used to be beaten to free it from dust, but the name of *willowing* applied to a machine process remains as evidence of the ancient practice. Fibres have still to be *combed* or *carded* with the object of clearing out the portions that are not wanted, and of presenting the remainder in a handy form for spinning into yarn.

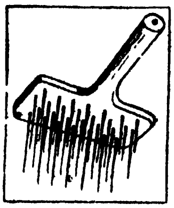
Hand Combing. Probably the *comb* or *hackle*, somewhat in the form of a rake, is the most ancient of tools used in preparing fibre for spinning [1]. Its essentials were a head or *stock* to hold the teeth, and a handle with which to wield the tool. The combs used for wool varied in coarseness of tooth, length of tooth, and number of rows of teeth, according to the sort of wool in work. Two of the instruments were employed at once—one stationary, and called the *pad comb*, was fixed to a post with its teeth pointing sideways; the other was worked by hand with the teeth downward. The material was first lashed across the teeth of the fixed comb, and worked adroitly into the teeth of the working comb, the refuse or *noil* being left behind. The combs were heated in a *pot* or stove, the wool was oiled so that the fibres should slip over each other more rapidly, and when fully charged the combs were exchanged, the working comb becoming the pad comb and *vice versâ*. The process of combing was essentially one applied to the long fibres such as were spun from the *distaff* or *rock* in times before the introduction of the spinning-frame. The combings or *tops* were drawn off the comb by hand, and formed into a continuous *sliver*, composed of fibres all of approximately the same length and all laid parallel, side by side.

Hand Carding. The *card* resembled a brush rather than a rake, and had a great number of short wire teeth or bristles set at a slope. The teeth were inserted one at a time in a foundation of leather, and this piece of *card-clothing*, when fully finished, was nailed down upon an oblong of wood to which was attached a sloping handle. The cards [2] were essentially for short-fibred material, and were used in pairs. One having teeth sloping away from the worker was fixed at a convenient height, teeth uppermost; and the other, with teeth inclined in the opposite direction, was held in the hand. The material was worked well down into the teeth of the cards, and was removed in a veil or film by rolling over the teeth a stick furnished with sharp points to pick up the carded wool or cotton, and present it in the form of a roll of interlocked filaments.

The Spindle. The oldest and most fundamental spinning appliance is the spindle, to which was subsequently added the wheel. The wheel simply gave an improved means of rotating the spindle, and facilitated an operation that had been carried on from time immemorial. The primitive spindle was a spike of wood, notched at one end to hold the yarn during the operation of twisting, and weighted near the other end with a ring of wood, clay, or metal to lend momentum. A twist of combed material was drawn off from the distaff by hand and attached to the notch, the sliver being reduced in thickness in the act of drawing off. The spindle swinging at the end of the drawn sliver was set rotating by giving its bob or weight a rub between the thigh and the hand. Thus the yarn was twisted, and when it had been drawn sufficiently thin, and been given twist enough to make it strong enough for the purpose in view, it was wound upon the shaft of the spindle between the weight and the notch, and a fresh length was drawn off and spun. Carded material drawn from the roll was reduced to what is still called a *roving*, a sort of semi-yarn, and spun in the same way.

Once the universal employment for women, spinning required some manual dexterity. The actions became almost automatic with practice, and could be carried on even on horseback as they still are by tribesmen in Central Asia. Spindles varied in weight and size with the coarseness of the yarn spun, and ranged from formidable implements over a foot long down to steel pins hardly bigger than a darning-needle, or to tiny splints of bamboo.

The Spinning Wheel. The wheel introduced to drive the spindle carried a band or belt, which passed round a grooved ring or *whorl*, attached to the spindle; and the wheel was revolved at first by hand and later by crank and treadle. Wheels were sometimes set to drive two spindles so that the industrious spinster could control two threads, one with the right hand and one with the left. Wheel-spinning involved the same three operations of drawing out the fibre, putting in the twist, and winding up the completed yarn.



1. HAND-COMB

About 400 years ago the first traces appeared of the improved wheel which made twisting and winding-on simultaneous. The spindle was fitted with a *flyer* [3] and a *bobbin*, which were rotated independently and at different speeds.

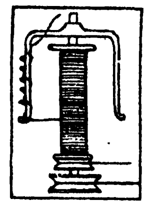
The Flyer. The flyer, first introduced in the *Brunswick flax* or *little* spinning-wheel, formed one of the greatest improvements ever made in textile machinery, and flyers are still used at one stage or another in all systems of spinning. The bobbin (instead of the bare spindle) received the yarn, and its rotation at a higher speed than the flyer gave the yarn its twist. The flyer was a piece of light metal or wire with bent legs, fitting upon the top of the spindle and astride of the bobbin. The roving, drawn by the spinster, passed through an eye near the pivot of the flyer, was twisted once or twice around a leg of the flyer and, by means of *hecks* or hooks upon the leg, was delivered at right angles to the bobbin so that it could be continuously wound. The system of hecks was the clumsiest feature of the original flyer, and the purpose of having several of them down the flyer-leg was to obtain uniformity of winding-on. The spinster had to move the thread at intervals from heck to heck, in order that all parts of the barrel of the bobbin should receive their share of yarn, and that the bobbin should not be much more thickly wound in one place than another.

2. HAND-CARDS

Drawing Rollers Introduced. Upon the wheel the drawing, or attenuating, of the sliver had to be done by the spinster's hand, and until 1738 there was no mention of an attempt to make rollers do the work. Wyatt, of Birmingham, conceived the idea without bringing it to a successful issue, and it remained for Arkwright to make drawing by rollers a practical success.

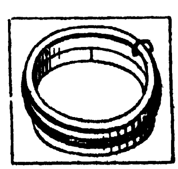
The principle is simple, and its working involves two pairs of rollers. The sliver, prepared for spinning, is passed between both pairs, and they are set tightly enough to nip the material in passing. The back rollers, which receive the material first, rotate at one speed, and the front rollers at a higher speed. The front rollers accordingly deliver the material faster than it is fed to them, a thing that they can only do by drawing the fibres of the sliver out. The fibres are pulled endwise over each other as they were when the spinster drew from the distaff or the roll. The principle has been refined upon, and the operation of drawing as done by modern machinery is one of the most delicate and carefully adjusted of any, but the relative speeds of different pairs of rollers remain the controlling factor in all cases.

Frame Spinning. The combination of flyer and rollers gave the world a spinning-frame on which the spinning proceeded continuously, instead of intermittently, as upon the wheel. The frame could be made with a large number of spindles, and the incidental improvements added to it in the course of time enabled the spindles to turn at a high speed, and thus effect a large production. The hecks of the original flyer were dispensed with in favour of an eye, or *twizzle*, formed by bending the flyer leg at its foot, and an up and down motion imparted to the bobbin laid the yarn evenly in successive layers. In modern practice, the flyer is screwed upon the top of the spindle, and the bobbin around which it rotates is dragged round by the pull exerted through the yarn; but this is a change less of principle than of detail.



3. FLYER

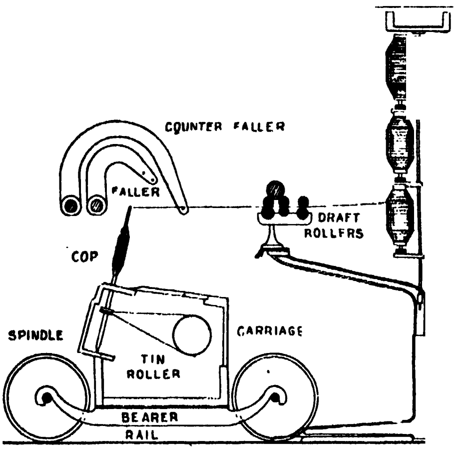
The Spinning Mule. Arkwright's invention of the *water twist* frame got its name not from any water used on the frame, but from the fact that it was designed to be driven by a water-wheel. Its invention was followed in a few years by Crompton's *mule*, and both inventors incorporated features that had been used by Hargreaves in his spinning-*jenny*. The jenny was an intermittent machine for stretching the yarn at one operation, and twisting and winding-on after the pause in which the stretching was done. The same sequence is followed by the mule. Nearly fifty years passed before the mule was made fully automatic by Roberts, of Manchester, and although hand-mules are rather curiosities than utilities in these days, the modern machine is often spoken of as the self-actor.



4. RING TRAVELLER

The mule is used mainly for spinning short fibres, and for producing a spongier yarn than can be made upon any of the continuous spinning frames. It consists in the first place [5] of a *creel*, or stand, to hold the bobbins of rovings. The rovings are led through three pairs of drawing or *drafting* rollers to a spindle. The spindle, which is driven by a band from a tin roller, is mounted upon a *carriage*, or movable front of the machine, and this carriage is on wheels mounted upon rails or *slips*. The motions of the machine follow each other in a cycle. First comes the spinning motion during which the

drafting rollers work rapidly. At the same time, the carriage carrying the spindles begins to move outward on its rails, and the spindles are driven at high speed to put in the twist. The drawing done by the rollers, and the stretching given by the outward run of the carriage, pull the fibres over one another and reduce the diameter



5. SPINNING MULE

of the roving. Thin and weak places occur in the roving as a consequence of this treatment, and for this reason twist is thrown energetically into the yarn while the stretching is in progress. The twist finds its way to these places first, and strengthens them. The yarn spun during this part of the cycle is wound upon the bare spindle near the point, and at the end of the stretch the spindles stop. The spindles reverse the direction of their rotation, so that the spun yarn is unwound rather slowly. The carriage reverses its direction and begins to run home. A wire, called the *faller wire*, descends and guides the spun yarn into position for winding-on upon the tube, or *cop*, that clothes the lower part of the spindle. Simultaneously another wire, called the *counterfaller*, rises to pick up the slack, and during the return traverse of the carriage the spindles are turned still more slowly to wind on the yarn.

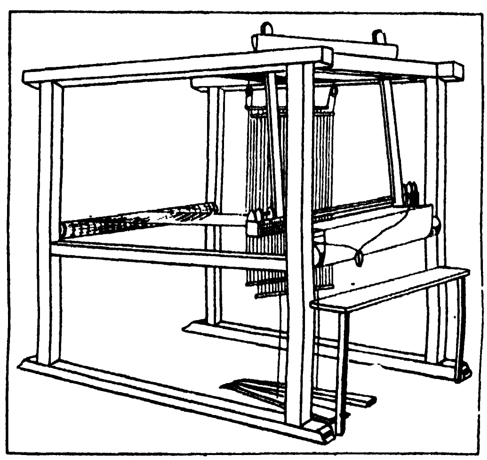
The mechanism is complex, and the machine, with its carriage for stretching 64 inches of yarn at once, occupies a relatively large floor space. It is the most wonderful of spinning machines to watch, and its successive motions exactly duplicate the actions of the spinster working a spinning-wheel on which no flyer is fitted.

Cap Spinning. Two other systems of continuous spinning, introduced some eighty-five years ago, provided alternatives to the use of the flyer. In both of these the spindle is stationary, and in both cases the object was to attain higher speeds. The flyer sets up a vibration at high speeds that is detrimental both to the yarn and to the spindle upon which it is mounted, although within its own limits it is unexcelled in producing smooth yarn. The *cap* frame, although used largely in spinning fine worsted, has few other uses at the present day. The *dead*, or stationary spindle, is fitted with a hollow steel cap, and with a tube or barrel. A peg upon the barrel engages with a hole in the bobbin, so that the tube and bobbin are driven round together at the same speed. The bobbin is given an up-and-down motion during the process of spinning so that it works in and out of the cap. The edge of the cap guides the yarn, and the light friction in passing exerts drag enough to cause the yarn to wind on.

Ring Spinning. The system of *ring* spinning, which has become of the first importance, derives its name from a flanged ring of steel, encircling the bobbin. One of these rings is set in a rail over every spindle, and the *lifter-rail* is adjusted to move upward gradually, and to sink downward sharply, in order to build the yarn upon the bobbin in the desired shape. The bobbin is secured by a peg to a small plate driven by a whorl, and the yarn, before running on to the bobbin, is passed through a *traveller* which slides round the flange of the ring. The ring-traveller [4] is a C-shaped bent wire, of just sufficient weight to make the yarn taut and cause it to wind on.

Ring frames spinning fine counts of cotton are driven at speeds up to 9000 revolutions a minute, as against the 2300 that are practicable upon the ordinary flyer spindle. The ring system of spinning and doubling is extending in many directions, but it may be noted, as one of the chief differences between English practice in cotton spinning and practice in most other countries, that we use principally mules and they principally ring frames.

The hand combs and cards have evolved into a series of complex machines, arranged progressively to carry forward by degrees the straightening or the intermixture of the fibre.



6. HAND-LOOM

Between the cards or combs stands an array of preparing machinery for carrying on step by step the sequence of processes that is only completed upon the spinning-frames. Their broad effect is to do what was less perfectly done by hand. Consideration of their detail must be deferred to a later stage.

The Hand Loom. We may pass to the loom, an apparatus that in one form or another is as old as civilisation. In its most primitive form the loom was the simplest possible arrangement for holding one set of threads parallel, and enabling another thread to be inserted between alternates. The threads of the warp were secured to a beam, usually a straight bough of a tree, and this was fixed to the ground. Rods, such as are now called *lease-rods*, were inserted between the odd and even threads to part them from each other, and it would seem from Egyptian tomb-drawings that the weft was inserted in the *shed* thus formed by pushing it through with a stick. The threads thus placed were beaten well home with a heavy lath or *sword*, and the weaving was done by two women, posted at each edge of the cloth.

At a later stage the *reed* was introduced to give greater regularity to the warp, and between the wires, in what are called the *dents* of the reed, the warp threads were passed in couples. The reed is a sort of comb, built of flattened wires placed parallel and close together, and secured in a four-sided frame made by binding laths of wood together with twine. At a still later date *harness*, *healds*, or *heddles* were added, to give an improved means of separating the threads; these were mounted on *shafts* supported from overhead. Each thread of warp was passed through a loop or eye of the healds, and in simple weaving one shaft carried the odd numbers and the other the even numbers. By raising first one shaft and then the other, a shed or parting was formed more quickly than by the use of rods. By enclosing a spool of yarns in a boat-shaped shuttle, the weft was thrown across the opening from hand to hand.

Improved Hand Looms. These arrangements were transferred to the built-up hand-looms evolved from such crude apparatus as is still worked in India at the ground level. The parts were fitted into a wooden frame [6] comprising a warp beam, or roller, on which the warp was wound. The warp beam was hung in brackets, and a weighted rope passed round its ends prevented slipping, and held the threads taut between the warp beam at the one end of the loom and the cloth-roller at the other. The heald shafts, suspended from a cross-bar overhead, were placed midway, and a couple of treadles arranged conveniently for the weaver's feet enabled him to raise the shafts in succession. The reed was swung from above in a hinged frame or *batten*, and just in front of the reed was the shuttle *race*.

In some parts of this country shuttles were thrown by hand across this race for long after Kay's invention of the fly-shuttle in 1733, an improvement which added greatly to the speed of weaving. Kay fitted the loom with *boxes* at each side of the race, and into these the shuttle was driven alternately from side to side. A blow from a strap was the means of propulsion, and these straps were attached to *picker* arms, or sticks. A sharp tug on the cord held in the weaver's hand drew out smartly in turn the one arm or the other, and the strap shot the shuttle out of the one box into the box opposite, when it was brought to rest. The weft was beaten home by swinging the reed and batten inwards. The cloth was maintained at width by *temples*, or pins, engaging with the *lists*, or edges. Warp was let off from the beam by the action of the weaver in winding the roller which received the woven cloth.

The Passing of the Hand Loom. The improved hand-loom is still in use in some factories for the weaving of trial patterns, although it is being expelled even from this field by power machines. The hand-loom engages the whole of one person's attention, whereas six or eight plain, narrow power-looms of the kind used on cottons in Lancashire can be managed by one weaver. The fastest of these looms make 300 picks a minute where the hand weaver, perhaps, made fifty. There are automatic looms of which one weaver can superintend thirty-six, but in the elements of every type of power-loom in general use today the features of the hand-loom reappear. No radical departure from the original principle in weaving has yet been brought to commercial success, and the persistence of the ancient principles throughout the whole mass of modern improvements in textile machinery is one of the most impressive and significant facts with which the student is faced.

Incidental Machinery. Reference has been confined thus far to what may be called the capital machines, but in all times there have been incidental operations to perform. Thus yarn intended for warps had to be laid out at length in parallels. The manufacturers of the past used the method of *peg warping*, or, in other words, hung the yarn over and under a series of pegs standing out at right angles to a wall. The yarn was carried over these until a sufficient number of *ends* had been prepared to form the fabric, and then the threads were cut, mounted on the beam, and led through the loom harness. There is now an almost universal use of *warping mills*, in the form of cylinders many yards in circumference, around which are wrapped ends of yarn proceeding from bobbins that have been set in a frame or *creel*.

Winding Devices. Many types of machinery are employed in winding and re-winding yarns to befit them conveniently for use. The original type of winding machine appears to have been the *reel* used in winding yarn from its spindle, or bobbin, into *hanks* or skeins. The reel was a skeleton wheel in the form of a hexagon, and rotated by a handle. The circumference was of a known length, usually one yard or one and a half yards, and, by counting the revolutions, the number of yards per pound—or, in other words, the yarn *count*—was arrived at. Winding from and into hank, or from one bobbin to another in plain and cross motions, calls for a large variety of machines with especial suitability for different yarns and purposes. Such machines are treated in due order.

J. A. HUNTER

Temporary Stars. Star Clusters. The Milky Way. The Nebular Theory. The Birth of a Solar System.

THE THEORY OF THE UNIVERSE

THERE is no real distinction between irregularly variable and *temporary* stars. The latter, which create great interest among the public as well as among astronomers, are stars which once in history burst out into a sudden blaze, and then again shrink down to their former insignificance. The earliest recorded of these was seen by Tycho Brahé, in 1572, when a star which outshone even Venus and Jupiter suddenly blazed out in Cassiopeia. Within the last few years there have been well-known outbursts of the same kind in the constellations of Auriga and Perseus.

Very careful spectroscopic analysis has made is quite clear that in all these cases what we see is a veritable conflagration. Vast outbursts of incandescent gases suddenly well up from the interior of a quiescent and comparatively faint star, and raise it to a degree of luminosity which may rival that of vast and steady globes like Sirius or Vega. But such a star lacks the energy to keep up this output of light, and before very long dies away to its former faintness.

It has been supposed that the collision of two stars, or the falling of a vast planet into a tiny sun, might account for some of these sudden outbursts of light. Such an occurrence would certainly produce a blaze visible all over the heavens, but the collision of two stars is so improbable an event, in view of their vast distances apart, that we may eliminate it, and the falling of a planet into a sun has not as yet been known to occur. Probably it is bound to happen as systems grow old and decayed; it will certainly happen one day in our own system.

But the behaviour of our sun shows that the evolution of incandescent gas from a star's interior is quite a normal incident in stellar life. If the vast eruptions of glowing hydrogen which are daily emitted from the sun's surface were increased tenfold by some interior convulsion, the sun itself would blaze out as a temporary star—and, incidentally, life would be burnt off our planet. We can only say that the great majority of stars shine with fair regularity, and hope that the sun will continue to do the same.

A number of stars are arranged in clusters of groups, while others, like our own sun, are at vast distances from their nearest neighbours. Some of these clusters, of which the Pleiades afford the best example to the naked eye, can be resolved by a keen eye into separate stars; some, like Præsepe in Cancer, which only show to the naked eye as a hazy spot of light, break up in a good field-glass into clusters of stars; but the majority of stellar clusters require a powerful telescope for their resolution.

It was long ago noticed that, the more powerful a telescope was, the greater was the number of these hazy spots of light which it would resolve into clusters of stars. Consequently the opinion was formed that all the hazy little clouds or *nebulæ* which are so prevalent throughout a large part of the sky were simply clusters of stars, so far away that their light merged into a single impression on the eye. A great number of these nebulæ were only resolved by large telescopes, such as Lord Rosse's six-foot reflector; many were found to be irresolvable by any telescope. It was simply concluded from this that they were still more distant than the clusters which had yielded to the resolving powers of the telescope; and it was further supposed that each of these clusters of stars might be a separate universe or galaxy, comparable in extent and importance with our own universe, bounded by the vast girdle of the Milky Way.

This grandiose conception of innumerable universes scattered throughout space was speedily destroyed by the spectroscope. As we have seen, the spectroscope distinguishes with entire certainty between the light sent to us from a solid star and that emitted by a gas. When it was turned upon the nebulæ which had been supposed in reality to be star-clusters so distant that no telescope could resolve them, it showed unmistakably that these nebulæ were not star-groups, but simply masses of incandescent gas.

The Structure of the Universe. At the same time, improvements in the methods of measuring parallax caused astronomers to revise their somewhat exaggerated notions as to the distance of the faintest visible stars. They have, in consequence, mostly given up the theory of innumerable universes in which the fancy of an earlier generation was pleased to run riot, and have formed a fairly coherent though still somewhat vague idea of the actual structure of the universe, of which a short account must now be given in conclusion.

The most casual inspection of the starry heavens shows that the visible stars are very irregularly distributed. Some regions are crowded with stars, while others show a very sparse distribution of orbs visible to the naked eye. The telescope, while vastly increasing the number of stars up to about 30,000,000 visible to the most powerful instruments, still emphasises the irregularity of their distribution.

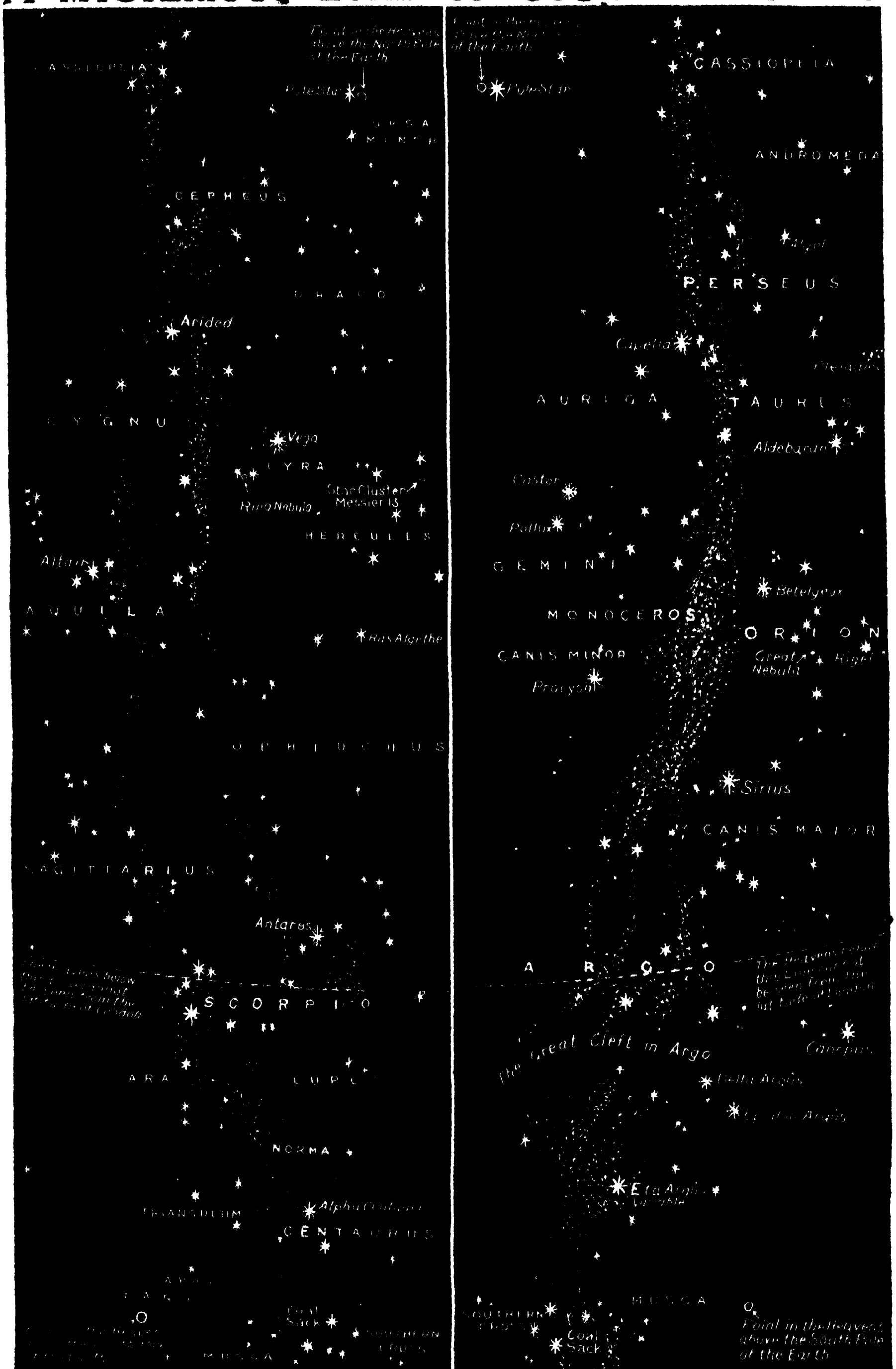
The Galaxy. There is one region of the sky which is far more thickly strewn with stars than any other. This is the luminous belt which surrounds the whole sky nearly in a great circle, which is known as the Milky Way, or the Galaxy. To the naked eye it usually seems to be a luminous cloud, though on a very clear night it is possible for keen eyesight to make out here and there the brightest of the individual stars which compose it. The telescope and spectroscope agree in showing the Milky Way to be composed of innumerable stars, mostly of the eighth magnitude or smaller, and set so closely together that the whole belt of sky which they inhabit seems to be luminous.

A NEBULA IN CYGNUS
From a photograph by Mr. C. W. Ritchey

The Milky Way contains very numerous clusters of stars, but very few gaseous nebulæ. The rest of the sky nowhere contains any such crowding of stars as is found in the Milky Way, though here and there we find a bright cluster, like Præsepe, where several thousands are condensed within a space much smaller than the full moon. The stars frequently seem to run into streams and groups, but on the whole their distribution is irregular and their number small in comparison with those of the Milky Way.

The Milky Way an Illusion. There is only one hypothesis which at present gives any reasonable explanation of this distribution of the stars. We cannot believe that the stars which form the Milky Way are really crowded together so closely as they look. The Milky Way is purely an effect of perspective. If we suppose the stellar universe to have the form of a vast flat disc, something like a crown-piece, of which the diameter is much greater than the thickness, and our own sun to be situated some-

A MYSTERIOUS ZONE OF COUNTLESS STARS



PATH OF THE MILKY WAY THROUGH THE TWO HEMISPHERES OF THE HEAVENS

These two drawings show the two semi-circles of the Milky Way as they extend from the region of the Polar Star to the region of the Southern Cross on each side of the apparent sphere of the heavens. It will be noticed that the bright stars congregate near its region, and that there is a characteristic harmony in the way in which the wisps appear to project into space, suggesting some common cause for this appearance throughout the whole galaxy.

where near the centre of this disc, a little thought will show that we should get substantially the same appearance as has been described. When we look along the plane of this disc the line of sight travels through thirty or forty times as many stars as when we look up or down at right angles to the plane of the disc, provided that the stars are distributed in all directions with fair equality. Consequently to an observer near the centre of the disc there will appear to be a nearly circular belt thickly strewn with stars, while the rest of the sphere is much less thickly set with stellar orbs.

It is now generally held that this is roughly the arrangement of our stellar universe. There are many modifications in detail, based on the distribution of various kinds of stars and on the details which form the Milky Way, but these must be studied in more elaborate works, such as Miss Clerke's "System of the Stars." It is enough to say here that the probability is that our sun is near the centre of the stellar universe; that this universe consists of at least 100,000,000 stars comparable to our sun, but many of them vastly brighter and more massive; that these stars are arranged roughly in the shape of a circular disc, of which the diameter is many times greater than the thickness; that the central part of this disc, near which our sun is situated, is much less thickly set with stars than the outer parts; and that its diameter is at least so great that it would take light 30,000 years to cross it.

The Nebular Theory of the Universe. It remains to add a few words as to the theory now accepted of the development of this universe and of systems like our own. We have seen that bright stars are divided into various types, according to their different spectra and colours. Some of them are undoubtedly hotter, and therefore younger, than others, and it is practically certain that there are many stars in the void of space which have grown cold and dark, so that we can never see them, though in some cases we are able to infer their existence from their gravitational influence on the neighbouring bright stars. Further, the universe contains a great number of nebulæ, which are merely clouds of incandescent gas. It was first suggested, by the great philosopher Kant, that these nebulæ might be the raw material of suns with their attendant planets. The physical conditions dominating the history of such nebulæ have been fully worked out by several generations of mathematicians.

The Birth of a Solar System. Suppose that we have a nebula or cloud of incandescent gas some 5,000,000,000 or 6,000,000,000 miles in diameter. This nebula must be subjected to two distinct causes of change. In the first place, all its material particles must attract one another by the law of gravitation, so that the nebula tends to condense toward the centre; and simultaneously, the incandescent particles which compose the nebula are constantly radiating heat out into space, so that the nebula must always be losing heat. On these two facts Laplace and his followers erected a complete theory of stellar evolution. Such a nebula cannot for a moment remain at rest, even if, which is exceedingly improbable, it was originally in such a condition. It would necessarily acquire a rotation about an axis, in addition to the movement through space which it would have under the influence of external gravitating bodies.

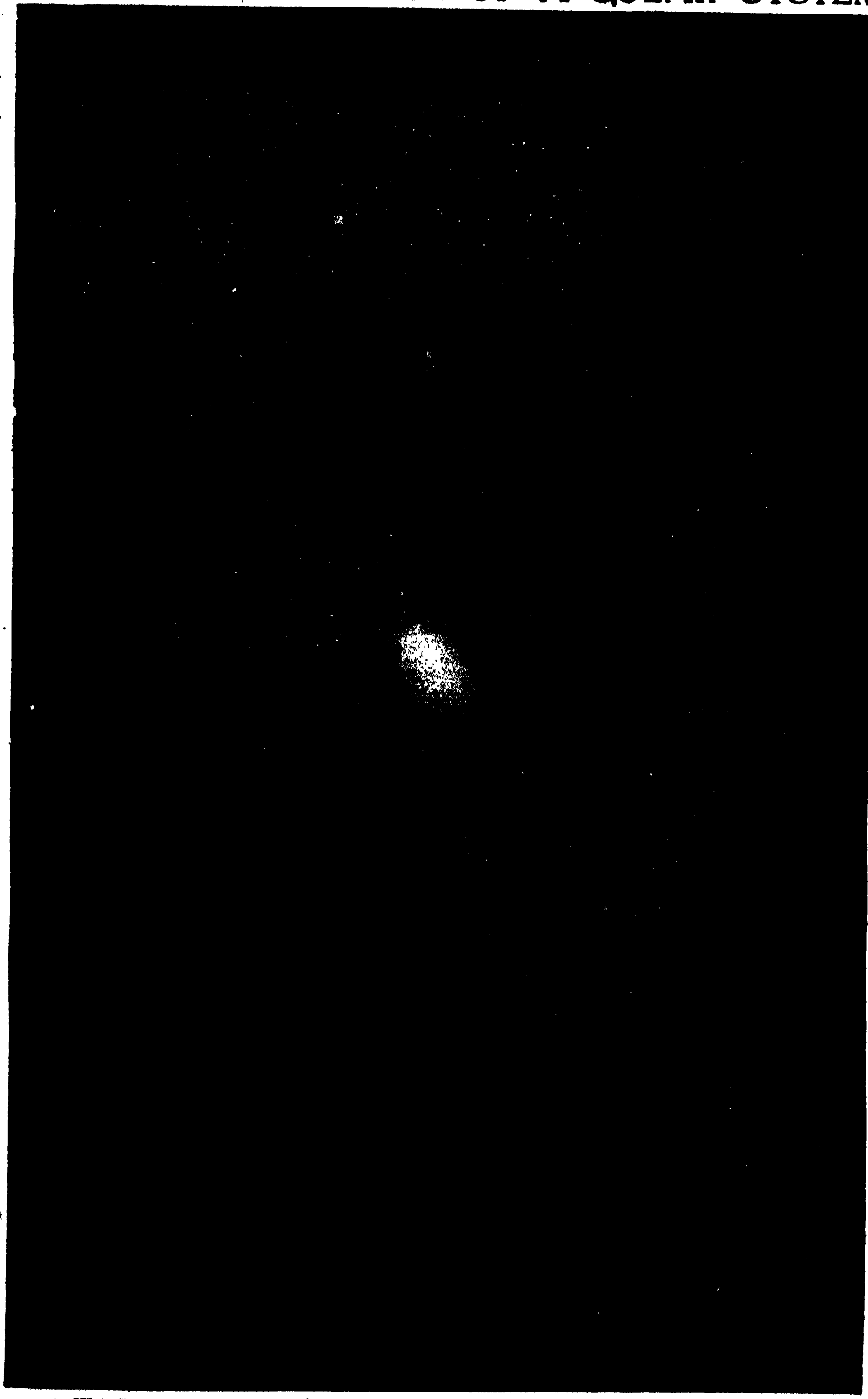
The Breaking-up of the Nebula. It has been shown mathematically that such a rotating nebula, losing heat at the same time and condensing inwards, would at regular intervals shed rings from its substance, and that these rings would tend to break up and coalesce into roughly spherical bodies or planets, which would revolve round the centre of the whole nebula and at the same time rotate on their own axes. Each of these rotating masses, if still hot enough to preserve the nebulous condition, would repeat the history of the original nebula, in turn shedding rings, which would coalesce into secondary spheres or satellites. Each of these derivative or secondary nebulæ, being much smaller than the parent nebula, would cool much more rapidly, and might become a solid body while the original nebula was still in the state of fiery gas.

This is believed to be the general history of the origin of the solar system, although further research has thrown doubt on some of Laplace's ideas. Once it was a vast cloud of fiery gas stretching out beyond the orbit of the farthest planet. As it contracted, it shed rings, which broke up into planet after planet, each with its own satellites. Neptune and Uranus came first; then Saturn, where the first anomaly appeared, for one or more of the rings which Saturn shed in cooling did not coalesce into a spherical satellite, but remained as the wonderful arrangement called Saturn's Rings, which consist of a swarm of tiny meteorites or cosmic dust. Jupiter, the largest of the planets, was next formed. The next ring thrown off by the original nebula behaved like the rings shed by Saturn, and gave birth to the swarm of minor planets. Mars, Earth, Venus, and Mercury were next born in the same order.

The vast luminous orb which we call the sun, and which we have seen to be still in an intensely hot gaseous condition, is merely the shrunk and dwindled remainder of this vast original nebula. This is a brief sketch of what is known as the nebular theory of planetary evolution.

The Beginning and End. It is highly probable that the gaseous nebulæ which exist in great numbers in the heavens are all in an early stage of such evolution, and that all the stars which bedeck the sky are the product of earlier nebulæ, and are surrounded by planets like the sun. But we are now approaching a region which borders on the realms of imagination rather than research. The span of our lives is so tiny in comparison with the vast ages that must go to the growth of even an inconsiderable system like our own that man has as yet had no opportunity for verifying such a hypothesis. It may well be that the vast drama of stellar evolution passes

THE WHIRLING SOURCE OF A SOLAR SYSTEM



A WONDERFUL OBJECT IN THE HEAVENS—THE NEBULA IN ANDROMEDA

This photograph was taken by Mr. G. W. Ritchey at the Yerkes Observatory, Chicago

through an unending and recurrent cycle. We can mathematically foresee the time when the inexorable operation of physical laws will bring back planet after planet to crash into the sun, and the result of such a series of collisions should be to reproduce the fiery nebula stretching far out beyond our own orbit. It cannot, indeed, be as vast as the nebula from which we were born, as the whole system is constantly losing energy in the form of light and heat radiated into space, from which (so far as we know) it never returns. From such a nebula there would be brought to rest, and the whole mass of material which now composes the solar system voyages through space in the form of one dark, solid, and lifeless globe. Possibly two such globes may dash together after millions of æons, and again break up into one vast nebula, instinct with that energy which contains the possibilities of living worlds. All this is pure speculation, and yet (as far as we know) it is the only course which the history of our system can take. That history is probably typical of what is going on throughout the universe. Everywhere there is a vast

THE VAST NEBULA IN ORION, WHICH EXTENDS MILLIONS OF MILES THROUGH SPACE
From a photograph taken at the Lick Observatory

produced a new system, with a smaller sun and fewer planets, again in the vast lapse of time to clash together, and to be expanded into yet another new nebula, still smaller and less potent.

A Cosmic Eternity. Thus we can dimly foresee the cosmic future as a kind of switchback, ever making smaller and smaller rushes up opposing hills, till ultimately the machine is recurrent cycle in operation, which evolves a solar system, and perhaps produces some race of sentient beings such as man, as a casual and temporary accident in this evolution. Even such a hasty survey of astronomical history as has been taken here teaches us to estimate the place of man in the universe with a somewhat truer sense of proportion.

W. E. GARRETT-FISHER

ASTRONOMY CONCLUDED

A short Dictionary of Astronomical Terms and Phrases appears at the end of the Self-Educator

Suction and Force Pumps. Double-acting Pumps. Worthington and Ashley Pumps. The Accumulator.

SUCTION AND FORCE PUMPS

Pumps. The pumps of the hydrostatic group are very broadly divisible under two heads, the lift or *suction* type, and the *force* pump. The important distinction between the two is that the first-named depends for its action on atmospheric pressure, and the second does not. It is usual to include these under the pneumatic branch of mechanisms, because the atmospheric pressure exercises an essential influence in the operation of the suction type. But it is more convenient, from the point of view of practical applications, to dispose of them here.

The suction group and the pressure group are found in many and varied designs. The first are limited to depths of water of about 24 ft., the second have practically no limitations. These, the *force pumps*, as they are called, are the ones that are invariably employed for pressure purposes, since there is no limit to pressure possible, save that of the strength of the bodies, and fittings, and valves of the pumps themselves.

The air enters into the operation of all pumps, but in the suction pump it is far more important than in the others. The point in the first-named is that there is nothing but the atmosphere as the acting agent, its pressure alone forcing the water up through the suction pipe and barrel, through the delivery valve. The limiting height is that from the delivery valve at the top of its stroke to the water-level in the well.

Suction Pumps. Figs. 82-86 are a selection of the essential mechanisms of various suction pumps. Fig. 82 is the common lift, or atmospheric pump in its most familiar form, with bucket A, having a hinged leather and metal-plated valve, and the clack B, also of leather, hinged and weighted with metal plates. The clack is prevented from rising too high by the stop piece C, as shown in 83. Leakage past the bucket is prevented by the leather packing D. Fig. 84 is a form less liable to get out of order than the one with leather fittings, besides being suitable for liquids that would destroy leather. The bucket-valve A, and the clack-valve B, are of the mushroom form—direct lifting. Both are prevented from lifting too high, A by the arch of the bucket, and B by the perforated plate C. If one of these valves opens to a height equal to one-fourth of its diameter, it will pass all the water which is possible.

A design often preferred is that with ball valves [85]. The advantage of these is that they will not only lift, but rotate slightly and constantly on their seatings, so equalising wear. Sometimes the mushroom valves in 84 are made with their wings disposed spirally, to cause them to turn slightly on their seatings at each lift. The height of lift of the ball valves [85] is slight, and each valve is enclosed in a cage with open sides, through which the liquid escapes. The example shown is one by Hayward-Tyler & Co., for deep wells.

The theoretical height of 34 feet can never be reached, due to leakages past the valves, and these may be so great in pumps having badly packed valves, or dried-up leather valves, as to prevent any lift of water until the leakage has been overcome by "fetching" the pump with water. The atmosphere at the commencement of pumping occupies the suction pipe. On lifting the bucket, the air expands, with loss of pressure, and the external air forces water up to occupy a portion of the vacuum. When the bucket has been lifted and depressed a few times, no free air is left, and the pump lifts solid water.

Air-pumps are also suction pumps. They draw the condensed steam and vapour mingled with air from the surface condensers of steam-engines. They are a group by themselves, having little resemblance to the pumps just noticed, though based on the same principles. Like these, too, though atmospheric pumps, they lift water charged with air when in full operation.

The first thing one notices about the action of the suction pump is that it discharges water only on the lifting stroke, or intermittently. This is objectionable for feeding purposes, and hence we have the treble-barrel arrangement. In this, three pumps are set side by side, each complete in itself, but driven from a common crank shaft, the cranks of which stand at 120° apart. Practically, a continuous delivery is thus obtained. In such pumps, the handle is discarded for a belt, or engine drive. Except for agricultural and domestic purposes, the lever handle is seldom used for pumps, but some form of power drive is applied.

Another way in which a practically continuous stream is obtained is in the double-action pump [86]. Here, the rod A of the lower bucket passes through the rod B of the upper one, and both are crank-driven in such a way that the buckets move in opposite directions, one lifting while the other is forcing, a partial vacuum being formed between the buckets. The bottom bucket takes the place of the fixed valve in the previous figures.

Force Pumps. In these, a solid plunger or ram is substituted for the bucket with a valve, or valves, and the delivery valve is in a portion of the pump body away from the ram. The ram, therefore—a solid piston—alternately creates a vacuum into which the water flows through the suction valve, and then forces it through the delivery valve. Water can be raised through great heights thus, or what is equivalent, against great pressures, as when used for pumping into steam boilers. Also, the ram being independent of the valves, it may occupy either vertical, horizontal, or angular positions. This pump is

also intermittent in action, delivering its water in a series of impulses, unless mounted in three-throw style [94] or fitted with an air vessel.

Plunger and Bucket Pump. There is another way of obtaining a continuous supply—namely, by the combination of a ram plunger with a bucket. Here [87] a bucket A, with valve, lifts the water, but on the down stroke the ram B displaces a volume of water equal to its own, and sends it out through the delivery valve C. Water being, therefore, discharged during both strokes, the supply is continuous.

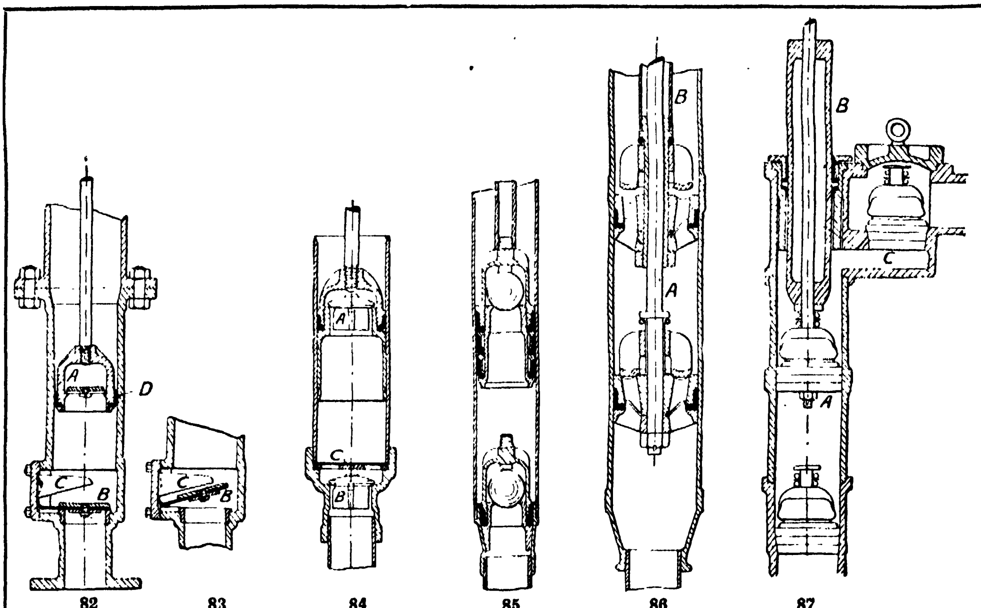
Double-acting Pumps. Though the foregoing pumps may be made to yield a continuous supply, yet they all suck water on one stroke and discharge it on the next, and are, therefore, nominally single-acting. When good duty is required, such designs are too wasteful, and then pumps that suck and discharge on each stroke are designed, hence termed double-acting, or duplex pumps. There are a good many of these. The two best-known forms are that in which a single piston operates two sets of suction and discharge valves arranged at opposite ends of a common chamber, and the Worthington type. In this, two pump chambers and engine cylinders are arranged side by side. The steam piston and pump pistons are at opposite ends of their rods, and the slide valves are operated by the piston of the fellow-engine. The pumps draw from a common suction pipe, but each chamber has its own suction and delivery valve. An air vessel is common to both.

Bore-hole Pumps. Where water is to be raised from bore-holes, a pump specially made for the purpose is employed. Figure 88 shows one of Robert Warner & Co.'s bore-hole pumps. The size and length of stroke vary from 3 in. upwards, according to the diameter of the bore-hole and the discharge required.

With this pump the usual suction valve is dispensed with, and in lieu of it a delivery valve is placed above the bucket. On the up stroke of the latter the water flows into the barrel; on the down stroke the water passes through the bucket valve as the latter descends, while on the up stroke it is lifted and forced through the delivery valve. The suction is fitted directly to the bottom of the barrel, so that the water flows straight up into it.

The bucket and delivery valve both come out and go down at the same time, and there is no separate operation required for withdrawing the foot valve, as is the case with ordinary pumps.

It is sometimes necessary to place a strainer on the suction pipe to prevent solid or gritty matter gaining access to the pump. Figure 89 shows Messrs. Hayward-Tyler & Co.'s foot valve and strainer for bore-hole pumps, while 90 depicts Messrs. Ham Baker's strainer for ordinary suction pipes.



82-87. TYPES OF SUCTION AND FORCE PUMPS

The Ashley Pump. This pump [91-93] was designed to supersede the old form of bucket and bottom valve pump, and to remove, in so doing, two of the difficulties experienced in connection with underground pumping. It is sometimes the case in this class of pumping, notably in wells, that the pump itself has to be placed at a great depth below the surface of the ground, and connected to the engine driving it by a corresponding length of rod.

In some cases, when a stoppage occurs, the water may rise in the pumping shaft to a considerable height (sometimes 200 ft. or 300 ft.) above the level at which the pump is fixed, and render it impossible, without the aid of divers, to

approach it from the outside for examination or repair. These conditions necessitate the use of a pump constructed so that all its working parts can be drawn up through the rising main when it is desired to effect any such examination or repair, and the diameter of the bucket must, therefore, be a little less than the diameter of the rising main through which it has to be drawn to the surface of the ground.

The type of pump mostly used hitherto in well bore-holes and mines consists of a bucket reciprocating in a working barrel above a fixed bottom valve, with which latter there is very frequent difficulty. This most vital part of the pump is, as a rule, the part most subject to violent shock and consequent breakdown, while, at the same time, to add to the difficulty, it is always extremely inaccessible.

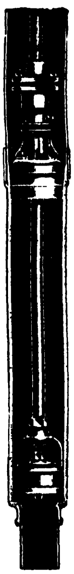
In the "Ashley" pump there is no bottom valve. The only working part is a single bucket reciprocating in the ordinary way in a working barrel. In this bucket are mounted the delivery and suction valves, so that when any examination has to be made, the whole of the working parts are drawn through the rising main to the surface of the ground.

The action of the pump is simple. On the up stroke the delivery valve (D V, **91**) is closed and water is lifted. At the same time the suction valves (S V) open, and water pours into the interior of the bucket and lower parts of the working barrel. Upon the down stroke the delivery valve opens and the suction valves close, and the bucket sinks to the bottom, ready to begin another up stroke, and so on.

The large waterway available in these pumps permit them to be worked at high speeds.

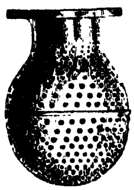
There are two distinct types of the "Ashley" pump. One [**91**] is the ordinary type for general work, while [**93**] illustrates the type employed where it is desired to work on suction—that is, to pump the water below the level of the pump barrel, as in sinking operations. The latter, however, is rarely used. The bucket employed with both types is the same, and is shown by **92**.

Figure **94** depicts a three-throw pump made by Messrs. Robert Warner & Co. The diameter of the pump is 4 in., with a 9 in. stroke, and is capable of raising 2000 gallons per hour, against a head of 200 ft.

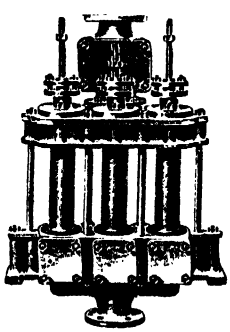


88. Bore-hole pump

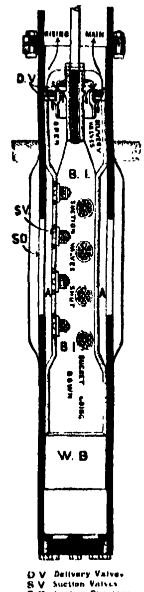
89. Foot valve and strainer for bore - hole pump



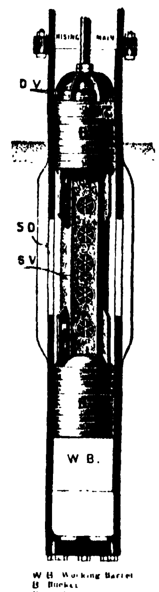
90. Strainer for suction pump



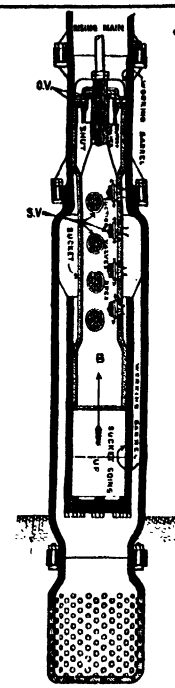
94. Three-throw deep-well pump



91. Ashley pump



92. Bucket of Ashley pump



93. Suction type of Ashley pump

88-94. PUMP DETAILS

The Worthington Pump. This form of pump meets the conditions as regards varying pressures that have been referred to, the delivery being uniform at all parts of the stroke. There are two pumps, each double acting, the flow from one dovetailing into the flow from the other. The steam cylinders, as will be seen from **95**, are directly in line with the pumps, there being no cranks or flywheels. This illustration shows an 800 h.-p. Worthington pumping engine. The low-pressure cylinders are 82 in., and the high-pressure 41 in. in diameter, the pump plungers being 12 in. in diameter. The steam pressure is 100 lb. per square inch. This engine works against a pressure of 1500 lb. per square inch,

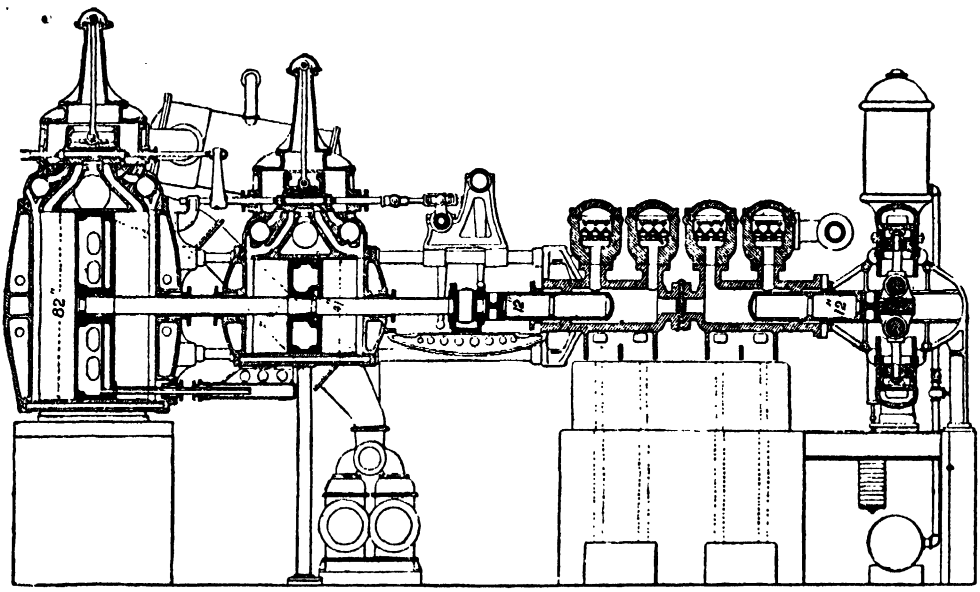
which is equivalent to working against a dead load of 151 tons.

A more recent form of this pump [96] has been installed at the East London Waterworks, and was constructed by Messrs. James Simpson & Co. The duplex pumping engine invented by the late Mr. Henry R. Worthington possessed reliability and simplicity, but was not economical in steam consumption. To accomplish this by a fly-wheel, or similar device for storing energy, would have taken away the characteristic advantages from the engine, so the Worthington compensating system was adopted, which permits the cutting-off of the steam in the cylinders, and its subsequent expansion to any degree or extent, thus giving to the direct-acting engine the advantages, as regards economy due to expansion, that are obtained by the fly-wheel engine, without in any way affecting the duplex principle. Figure 96 shows the engine constructed with this compensating arrangement. The attachment consists generally of two oscillating cylinders, supported from the main frames. These cylinders contain plungers, which are attached to the piston rods between the steam and the water ends. They are connected by pipes, and are filled with water or other fluid, to the surface of which air is admitted at a pressure suitable to the duty to be accomplished, for the purpose of maintaining a constant load at a practically constant pressure on their pistons through the medium of the liquid. The action of the plungers is to resist the advance at the beginning of the stroke, and to assist it at the end, the air meanwhile exerting its unvarying influence at each end of the stroke.

The two cylinders act in concert, being placed directly opposite each other, and perform the function of a fly-wheel. In the arrangement of piston rods the high-pressure ones are directly coupled to the pump rods. Between the high pressure cylinders and the pump end there is a cross-head to which are attached two side rods connecting to the low-pressure pistons. The piston rods between the intermediate and low pressure cylinders work through long sleeves, thus doing away with two stuffing boxes.

Pumping by Animal and Windmill Power. Animal power is often employed to drive small pumps. The animal is harnessed to a pole, and walks round and round, operating gear wheels which drive the pump.

The employment of windmills for driving pumps has been successful in many places, but as the results are dependent on the wind, tanks should be provided to store the water and to ensure a fairly constant supply.



95. THE WORTHINGTON PUMP

Speed of Pumps. The number of revolutions per minute to which a pump should work must depend on its construction. The chief thing governing the speed of a pump is the promptness with which the valves reseat themselves on the beginning of the return stroke. With multiple valves, which give a large waterway, with small lift, quick reciprocation may be secured. But pumps of the "bucket" type do not admit of multiple valves, and therefore require a pause at the end of the stroke to allow the valves to reseat themselves without undue shock. It is therefore necessary with pumps of this type to have a high bucket speed, which is obtained by lengthening the stroke.

The chief difficulty in working pumps is that of keeping the valves, etc., watertight, and it is here that plunger pumps are superior to piston and bucket pumps. The speed, therefore, should not exceed 30 revolutions per minute, but the average speed for ordinary working may be taken as about 25 revolutions per minute.

The speed at which a centrifugal pump should be run increases approximately as the square of the height of lift. The revolving wheel has to over-run the flow in that increasing degree, while the effect due to impact falls off with the increasing velocity of the wheel. High-speed centrifugal pumps attain a velocity at the impeller periphery of 40 ft. per second.

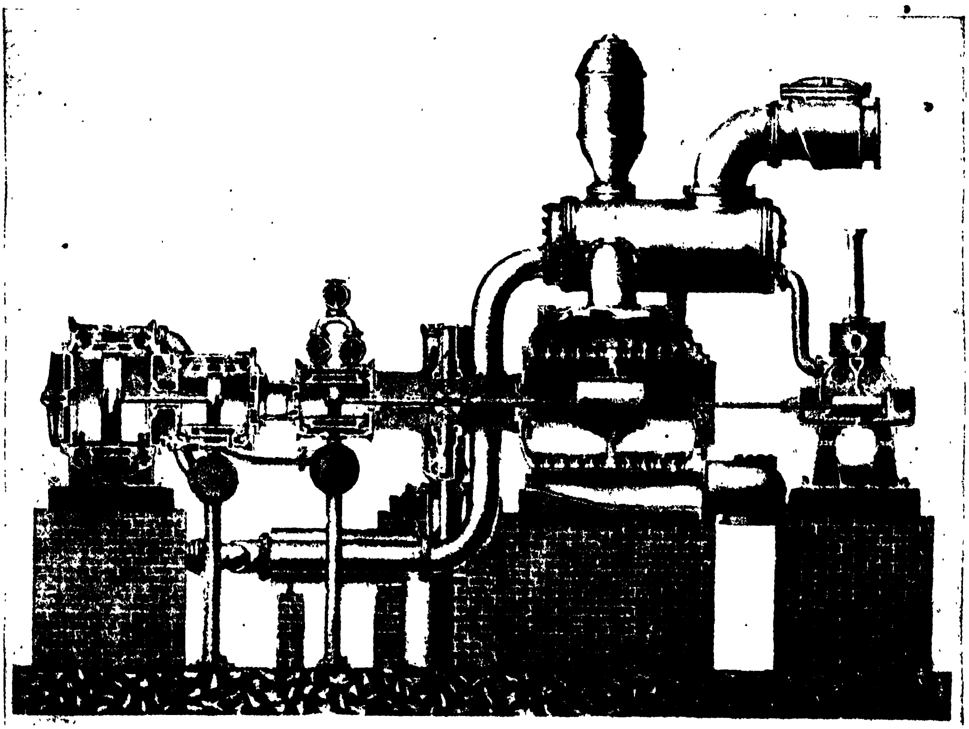
In selecting the best type of pumping engine to be adopted for any particular place, considerations as to working cost must not be forgotten. Professor Unwin, in his Howard Lectures on the "Development of Power," reduced all costs to one common standard—namely, "the cost of one pump horse-power maintained day and night continuously for one year, such horse-power being neither nominal nor indicated, but an actual 33,000 ft.-lb. of work measured in water raised per minute throughout the year." The advantage of this is that, having determined the height of lift, the cost per 1000 gallons of water pumped can be estimated.

The "duty" of pumping engines is expressed by multiplying the weight in pounds of water raised by the pumps by the height in feet to which it is raised for the consumption of a given quantity of coal in the boilers. It is usual in specifying for pumping plants to require the makers to guarantee a certain "duty" for their plant, which is to be stated as the number of pounds of water raised 1 ft. high per hour by 112 lb. of coal consumed in the boilers, on the basis of 10 lb. of water being evaporated per 1 lb. of coal. This coal unit is sometimes made 100 lb. instead of 112 lb. Taking the 112 lb. unit, the "duty" is calculated as follows:

1 horse-power = 33,000 lb. raised 1 ft. in 1 minute.
" " = 33,000 × 60 lb. raised 1 ft. in 1 hour.
" " = 1,980,000 ft.-lb. per hour.

Introducing the coal unit of 112 lb., and dividing it by the coal consumed per horse-power hour, we obtain a fraction which, if multiplied by the total foot-lb. per hour developed, will give us the "duty" as follows:

$$\text{Duty} = \frac{112 \times 1{,}980{,}000 \times 60}{\text{lb. of coal consumed per h.-p. hour}}.$$



96. SECTION OF A WORTHINGTON PUMP AT THE EAST LONDON WATERWORKS

As the "duty" is always expressed in millions, the formula becomes:

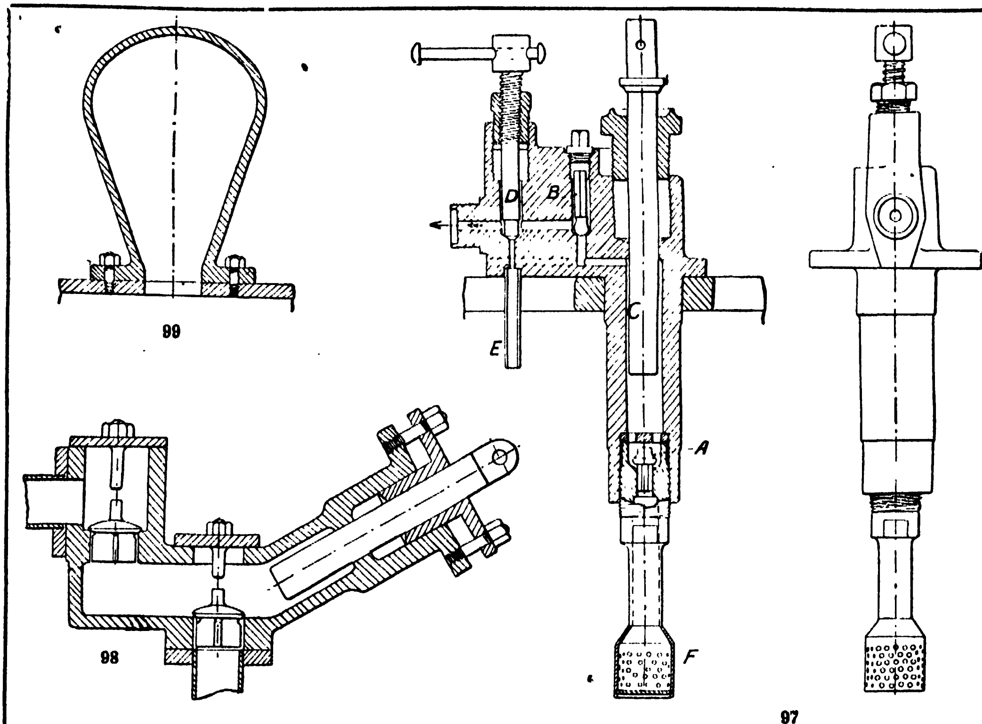
$$\text{Duty in millions} = \frac{221{\cdot}76}{\text{lb. of coal consumed per h.-p. hour.}}$$

In the early days of pumping plant a duty of 60,000,000 was considered good. With the increase of steam pressure and the use of compound and triple expansion engines, a 100,000,000 to 120,000,000 duty is quite usual at the present time, and may indeed be exceeded when it is desirable.

The Test Pump or Hydraulic Force Pump. This is a ram pump [97] indicated in connection with the press [76, page 1438], in which the water, practically incompressible in itself, is forced by a single-acting solid piston through valves and passages against the resistance of the work to be done. The latter may be any-

thing, but is essentially a mass resistance. It will be observed that the valves bear but a small proportion to the mass of metal in the body of the pump, which is usually specified to be strong enough to resist a pressure of 2000 lb., or more, in some cases, to the square inch. The body is of gun-metal, as are also the suction and delivery valves A and B. The ram C is actuated by the lever B [76, page 1438], and the water flows out through the passage indicated by the arrow. D is a relief valve for releasing the pressure by the lever seen above, the pressure water flowing away through E. The perforated rose, F, prevents any solid particles getting into the valves. The relation of this to the common force pump, one form of which is shown in **98**, will be obvious. The ram and valves are there, little way into its neck during the delivery stroke. When the backward non-delivery movement takes place, the air, thus compressed, forces down the water that had invaded the chamber, sending it along after the rest, so that a practically continuous stream results.

Simple examples of the utilities of the test pump [**97**] are the testing of steam boilers, and steam and water pipes, or the lifting of a baling press. The resistance is that of the metal in the first, or of the material to be compressed in the last. As the water will not yield, the tug-of-war lies between the strength of the pump on one side, and that of the boiler, or pipe, or press on the other. Then there is the utility of the pump for charging accumulators. As there comes a time when something would have



97-99. FORCE PUMPS AND AIR VESSEL

but the proportions are different, the pump being suitable for pressures of from about 60 to 100 lb.

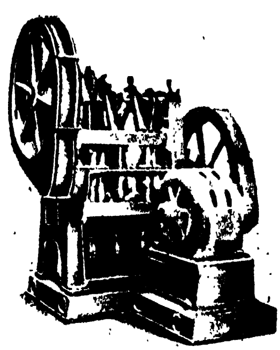
Air Vessel. The air vessel mentioned just now is not used on test pumps like **97**, because the volume of water pumped is extremely small, and has not to traverse far. In other words, there is no chance for the water to become saturated with air. But for long deliveries and for moderate pressures the air vessel is essential. One form is seen in **99**. It is made with a spherical end to ensure strength. Sometimes water will find its way through the pores of inferior qualities of iron. This vessel [**99**] is a chamber of large dimensions, fitted somewhere on the delivery side of the pump. It contains air, which, being elastic and compressible, becomes a cushion to the water that rises a to yield, the pressures are recorded on a dial gauge, and the pumps are fitted with relief valves. An advantage of the pumps is that the pressure may remain on for several hours, which is often a severe trial of strength of a boiler. These pumps occur in many forms, some being operated by hand levers, others directly connected to steam engines or electric motors.

Strength of Pumping Machinery. The strength of the pumps and machinery must be in proportion to the head of water against which they have to pump. The pressure per unit of area is independent of the area of the pipe, but additional work is thrown on the pumps if the pipes are too small, or if they have sharp bends, owing to the friction caused thereby. Let D = diameter of pump in inches, S = stroke

in inches, N = strokes per hour, then $D^2 \times S \times N \times \cdot 00284$ = contents of pump in gallons per hour. Thus, a pump 2 in. bore × 9 in. stroke, making 1500 complete strokes per hour, would deliver 151 gallons per hour, if there was no waste; but a percentage of water always slips by the valves at the end of each half-stroke, and it is usual to allow about 25 per cent. for this loss.

100. AIR VESSEL

To obtain a continuous and even delivery of water, and to reduce the shock on the valves at the reversal of the stroke, pumps have been constructed with two and three plungers discharging into a common rising main. The plungers work in rotation, being operated by cranks on the same shaft. The illustration [101] shows a three-throw pump manufactured by Messrs. Hayward-Tyler & Co. In this case the pump is operated by an electrical motor of 15 horse-power. The plungers of the pump are 5 in. in diameter, with a 9 in. stroke, the revolutions being 46·5 per minute. This pump is capable of discharging 50,000 lb. of water per hour against a pressure of 160 lb. per square inch.



101. THREE-THROW PUMP

In the crank and fly-wheel type the pump piston speed is variable, according to the angularity of the connecting-rod, and the quantity of water varies from zero at the ends of the stroke to a maximum at about half-stroke, when the pistons are moving with a velocity equal to that of the cranks. This, it will be noted, causes a variation in the rate of delivery of the water in the rising main. The severe pressure that would be set up in the pump (due to the inertia of the water, and the velocity) may be compensated for by placing on the rising main at the pump an air vessel, which acts as a buffer, or cushion of air, and takes up the shock. Figure **100** shows a form of air vessel that has been employed by the writer on several of the works that he has carried out. In cases where heavy pressures arise a difficulty exists in retaining the air in the vessel. It is therefore necessary to provide an air pump to supply the vessel with air as required during its operation.

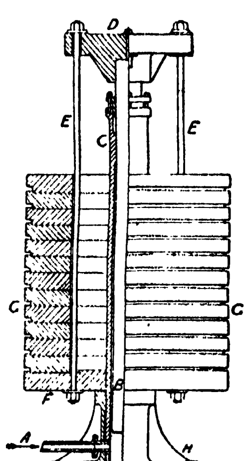
The Accumulator. As pumps are too slow in operation for rapid work, the accumulator [**102**] is fitted where rapid action is required. For example, imagine how slow would be the movement of a hydraulic lift at a railway-station if it were actuated directly by a pump, and the movements of a crane, also, or of a steel ingot press, or of a flanging press. Even a rapid-acting, high-pressure pump would be too slow for most machines in which hydraulic pressure is the motive force, and the precise and delicate regulation of pressure and speed which cranes, presses, and hammers require would be a practical impossibility. Lord Armstrong's invention of the hydraulic accumulator has, in fact, made possible almost the whole range of modern hydraulic machinery.

In these cases the pumps fill the accumulator until it is charged with many gallons of water under a pressure of from 750 to 1500 lb. per square inch, the latter being equal to 100 atmospheres. On opening communication between the accumulator and the lift or crane, or press, the pressure-water works it at a speed capable of regulation. The pressure or resistance of the accumulator is obtained by loading its casing with weights to the 700 or 1500 lb. required per square inch.

In **102** the parts are as follows: The pressure-water entering at A raises the ram B in the cylinder C, standing on the base H. The cross-head D attached to B, rising with it, receives rod E, on which is hung a plate, F, carrying a number of circular weights, G. The water being pumped, therefore, has to overcome the resistance of these weights, which, when raised, become the source of stored-up energy for doing work by their descent. The water passes to the machine, being operated through a tube (not shown) similar to A. The weights are made removable to permit of regulating the pressure according to the number used at any time. For convenience, it is arranged that each weight makes a difference of 100 lb. in the pressure. In the older accumulators, and in many at present, a casing of sheet metal (the weight-case) is used instead of F, and loose stone or iron is loaded in. The advantage of this is that the expense and trouble of transporting weights is avoided, since any rubble may be used on the spot.

The cast weights already mentioned provide a convenient means of regulating the pressure with precision, as stated.

We have now to note some of the common applications of the hydrostatic press and accumulator to manufactures and industries, which will occupy the next article of this course.



102. ACCUMULATOR

Latin: Irregular Verbs. English: Composition.
French: The Negative. Spanish: Regular Verbs.

LATIN

Continued from page 1442

By Gerald K. Hibbert, M.A.

SECTION I. GRAMMAR

Irregular Verbs: Third Conjugation

Continued

Perfect reduplicates, Supine, *-tum* or *sum*.

pendo	pependi	pensum	*weigh*
tendo	tetendi	tensum (tentum)	*stretch*
disco	didici	—	*learn*
posco	poposci	—	*demand*
curro	cucurri	cursum	*run*
pungo	pupugi	punctum	*prick*
tundo	tutudi	tunsum, *or* tusum	*thump*
fallo	fefelli	falsum	*deceive*
parco	peperci	parsum	*spare*
pario	peperi	partum	*bring forth*
cado	cecĭdi	casum	*fall*
cædo	cecīdi	cæsum	*cut, beat*
cano	cecini	cantum	*sing*
pango	pepigi	pactum	*fasten*
tango	tetigi	tactum	*touch*
pello	pepuli	pulsum	*drive*
tollo	(sustuli)	(sublatum)	*raise*

-i with lengthened stem-vowel, *-tum* (three *-sum*).

facio	feci	factum	*do, make*
jacio	jeci	jactum	*throw*
linquo	liqui	-lictum	*leave*
vinco	vici	victum	*conquer*
ago	egi	actum	*do, drive*
frango	fregi	fractum	*break*
lego	legi	lectum	*choose, read*
fugio	fugi	fugitum	*flee*
edo	edi	esum	*eat*
fodio	fodi	fossum	*dig*
fundo	fudi	fusum	*pour*
capio	cepi	captum	*take*
rumpo	rupi	ruptum	*break*
emo	emi	emptum	*buy*

B. U- VERBS.

-i, -tum.

acuo	acui	acutum	*sharpen*

Also, *arguo* (prove), *exuo* (put off), *induo* (put on), *imbuo* (tinge), *minuo* (lessen), *statuo* (set up), *tribuo* (assign). *Metuo* (fear) and *nuo* (nod) have no supine.

luo	lui	luitum, *or* lutum	*wash, atone*
ruo	rui	ruitum	*rush, fall*
solvo	solvi	solutum	*loosen*
volvo	volvi	volutum	*roll.*

DEPONENTS.

Pres.	*Infin.*	*Pf. Ptc.*	
fungor	-i	functus	*perform*
amplector	-i	amplexus	*embrace*
nitor	-i	nisus, *or* nixus	*strive*
patior	-i	passus	*suffer*
utor	-i	usus	*use*
gradior	-i	gressus	*step*
labor	-i	lapsus	
morior	-i	mortuus	*die*
queror	-i	questus	*complain*
fruor	-i	fruitus (fructus)	*enjoy*
loquor	-i	locutus	*speak*
sequor	-i	secutus	*follow*
apiscor	-i	aptus	*obtain*
comminiscor	-i	commentus	*devise*
expergiscor	-i	experrectus	*wake up*
fatiscor	-i	fessus	*grow tired*
irascor	-i	iratus	*be angry*
nanciscor	-i	nactus	*obtain*
nascor	-i	natus	*be born*
obliviscor	-i	oblitus	*forget*
paciscor	-i	pactus	*bargain*
proficiscor	-i	profectus	*set out*
ulciscor	-i	ultus	*avenge*

Irregular Verbs: Fourth Conjugation

-ui or *-ivi, -tum.*

aperio	aperui	apertum	*open*
operio	operui	opertum	*cover*
salio	salui	(saltum)	*leap*
sepelio	sepelivi	sepultum	*bury*

-i, -tum.

comperio	comperi	compertum	*find*
reperio	repperi	repertum	*discover*
venio	veni	ventum	*come*

-si, -tum (one, *-sum*).

fulcio	fulsi	fultum	*prop*
sancio	sanxi	sanctum	*consecrate*
vincio	vinxi	vinctum	*bind*
haurio	hausi	haustum	*drain*
sentio	sensi		*feel*

DEPONENTS.

assentior	-iri	assensus	*agree to*
experior	-iri	expertus	*try*
metior	-iri	mensus	*measure*
opperior	-iri	oppertus	*wait for*
ordior	-iri	orsus	*begin*
orior	-iri	ortus	*rise*

NOTE. The following verbs, while apparently of the fourth conjugation, are really third:

Capio, cupio, facio, fodio, fugio, jacio, pario, rapio, sapio, quatio, compounds of *specio* and *lacio, gradior, patior, morior;* and in some tenses *orior* and *potior.* In their present stem forms they usually retain the *-i,* but not before *i,* final *e,* and short *er*—*e.g., capiam, cape, capere, capiendum.*

Morior and *orior* have future participles—*moriturus* and *oriturus.*

Orior is conjugated like *patior*, except a few forms which follow the fourth conjugation: *oriri*, *orirer*, etc. *Potior* follows the fourth, but occasionally wavers between third and fourth: *poterer* and *potirer*.

Verbs Compounded with Prepositions. Simple verbs are not so often used in Latin as verbs compounded with a preposition, the prep. either strengthening or changing the meaning. The following are the chief changes of prepositions in composition:

1. *A*, *ab*- become *a*- before *m*, *v* (*amitto*, *avoco*); *abs* before *c*, *t* (*abscedo*, *abstergo*); *as*- before *p* (*asporto*); *au*- before *f* (*aufero*). But *afui* (from *absum*).

2. *Ad*- becomes *a*- before *gn*, *sc*, *sp* (*ascendo*, *aspicio*, *agnosco*).

It remains *ad*- before *b*, *d*, *h*, *j*, *m*, *v*, and vowels, but is assimilated before other letters: *affero*, *assisto*.

3. *Con*- (for cum), and *in*, are written *com*-, *im*-, before *p*, *b*, *m* (*compello*, *imbuo*), but are assimilated before *l*, *r*: *colludo*, *irruo*. They remain unchanged before other consonants, except that:

Con- becomes *co*- before *h*, *gn*, and vowels: *coeo*, *cognosco*. Also, *ignosco*.

4. *Ob*-, *sub*-, are assimilated before *c*, *g*, *p*, *f*: *occurro*, *suffero*; except *suscipio*, *suscito*, *suspendo*, *suspicio*.

They remain before other letters, except *sustineo*, *sustollo*, *sustuli*, *surripio*.

Note omitto, ostendo.

5. *E*-, *ex*- are assimilated before *f*: *effero*. *Ex*- before vowels, *h*, *c*, *q*, *p*, *s*, *t*; *e*- before other letters: *educo*, *evoco*.

6. *Trans*- becomes *tra*- before *d*, *j*, *n*: *trado*, *trajicio*, *trano*.

7. *Dis*- (inseparable prefix) is assimilated before *f*: *differo*. It becomes *di*- before *s* with consonant (*distringo*) and certain consonants (*diruo*). Note *dirimo* for *disimo*.

8. *Re*-, *se*- (inseparable prefixes) add *d* in *reddo*, *redeo*, *redhibeo*, *redimo*, *redoleo*, *seditio* (noun).

In addition to the changes in the preps., there is a vowel change in the verbs themselves in becoming compounds—*e.g.*, *concutio* (*quatio*), *collido* (*lædo*), *explodo* (*plaudo*), *exigo* (*ago*), *conficio* (*facio*), *confiteor* (*fateor*), *retineo* (*teneo*), etc. The student must look these up for himself in the dictionary, as he comes across them in his reading.

SECTION II. SYNTAX

Questions to which an affirmative answer is expected are introduced in Latin by *nonne*.

When a negative answer is expected, by *num*.

When the answer is absolutely an open matter, by the enclitic -*ne* added usually to the first word of the sentence—*e.g.*,

Num putas bis bina esse quinque? = you surely don't think that twice two are five, do you?

Nonne Cæsar erat imperator maximus = was not Cæsar a mighty general?

Putasne me patris similem esse = do you think that I am like my father?

The above are all *direct questions*. In *indirect questions*—*i.e.*, questions depending on a verb—the verb in the question is subjunctive. "Whether" and "if" in such sentences are rendered by (1) *utrum*, followed by *an* or *ne*; (2) *num*—*e.g.*, *Rogavit utrum hæc vera essent annon* = he asked whether this was true or not.

NOTE. Distinguish between "whether" thus introducing a dependent clause, and "whether" used to express a condition; the latter is *sive*, a compound of *si* = if—*e.g.*:

Hæc, sive vera sunt sive falsa, nullo modo me movent = whether—*i.e.*, if—this is true or false I am not troubled by it.

IDIOMATIC SENTENCES TO BE PUT INTO LATIN.

1. Socrates was called to trial on the charge of corrupting the youth, but in reality because he had become suspected by those in power.

2. He is too wise to err, too good to be unkind.

3. He came to such a pitch of folly that he could not be persuaded to eat.

4. It was resolved to send ambassadors to ask what was the meaning of these repeated insults.

5. I hear that she died four years after returning home: I fear that her children are in very poor circumstances.

6. If you help me, I shall rejoice; if not, I shall not take it ill.

7. The enemy at once sounded a retreat. When he heard this, the general bade his men also retire.

8. I came to see you at once, inasmuch as I had received many kindnesses at your hands.

9. Although he was the first to leave the ship, he is not the man to be a coward.

10. I am different from what I once was; so it is absolutely necessary for me to remain at home for several days.

LATIN VERSION OF THE ABOVE.

1. Socrates in judicium vocatus est quod corrumperet juventutem, re tamen ipsa quia in suspicionem magistratibus venerat.

2. Sapientior est quam qui erret, melior quam qui inclementer agat.

3. Eo stultitiæ venit ut illi non persuaderi posset ut ederet.

4. Placuit legatos mitti qui rogarent quid vellent hæ tot contumeliæ.

5. Nuntiatum est mihi illam anno quarto postquam domum rediisset mortuam esse: cujus liberi timeo ne pauperrimi sint.

6. Si mihi subvenies (*note tense*), gaudebo: sin minus, haud ægre feram.

7. Hostes confestim receptui canunt. Quod quum audivisset imperator, suis quoque ut recedant imperat (*historic present*).

8. Statim veni te visum, ut qui multa beneficia a te accepissem.

9. Quamvis primus navem reliquerit, non is est qui ignave fugiat.

10. Alius sum atque olim fui: itaque me oportet plures dies domi manere.

SECTION III. TRANSLATION.

THE GREAT ERUPTION OF VESUVIUS.

August 24th, A.D. 79.

Extract from letter of Pliny the Younger to Tacitus.

Nec multo post illa nubes descendere in terras, operire maria. Cinxerat Capreas et absconderat: Miseni quod procurrit, abstulerat. Tum mater orare, hortari, jubere, quoquo modo fugerem; posse enim juvenem: se et annis et corpore gravem bene morituram, si mihi causa mortis non fuisset. Ego contra, salvum me, nisi una, non futurum: dein manum ejus amplexus, addere gradum cogo. Paret ægre, incusatque se, quod me moretur; jam cinis, adhuc tamen rarus. Respicio; densa caligo tergis imminebat, quæ nos, torrentis modo infusa terræ, sequebatur. Deflectamus, inquam, dum videmus, ne in via strati comitantium turba in tenebris obteramur. Vix consederamus, et nox, non qualis illunis aut nubila, sed qualis in locis clausis lumine exstincto. Audires ululatus feminarum, infantium quiritatus, clamores virorum. Alii parentes, alii liberos, alii conjuges vocibus requirebant, vocibus noscitabant. Hi suum casum, illi suorum miserabantur. Erant qui metu mortis mortem precarentur. Multi ad deos manus tollere: plures, nusquam jam deos ullos, æternamque illam et novissimam noctem mundo interpretabantur.

ENGLISH VERSION OF ABOVE.

Not long afterwards that cloud descended (*historic infinitive*) over the land and covered the sea. It had encircled Capreæ and blotted it out: it had removed from our sight the promontory of Misenum. Then my mother begged, exhorted, ordered me to flee in whatever way I might, (saying) that a young man could, and that she, weighed down with years and weakness of body, would die happy, if she had not been the cause of my death. I on the other hand (affirm) that I will not be saved unless with her: then clasping her hand, I urge her to quicken her step. She obeys reluctantly, and blames herself for delaying me. Now there are ashes, as yet, however, few and far between. I look back; thick darkness overhung us in the rear, and kept following us, pouring over the land like a flood. "Let us turn aside," I say, "while we can see, lest being knocked down in the street we be trampled upon in the darkness by the crowd of our companions." Scarcely had we sat down when night (was upon us), not a mere moonless, cloudy night, but such night as there is in a closed room when the light is extinguished. You could hear the wailing of women, the cries of infants, the shouts of men. Some were seeking by the voice, by the voice were recognising parents, others children, others wives. These were pitying their own fate, those that of their loved ones. There were some who, through the fear of death, prayed for death. Many raised their hands to the gods: while more still imagined that there were no longer any gods anywhere, and that this was the final and everlasting night for the world.

[This is a more or less literal translation, given in order to enable the student to make out the meaning of the Latin. He should not, however, rest content with merely translating Latin literally into English, but should polish and re-polish his English version until it reads well and smoothly. For models of translation see "Translations," by Jebb, Jackson, and Currey, published by Bell & Sons.]

Continued

ENGLISH

Continued from page 1445

By Gerald K. Hibbert, M.A.

PUNCTUATION—*Continued*

Other stops are:

The *note of interrogation* (?), placed at the end of all direct questions—as: "Who is there?" It is not used after an indirect or reported question—as: "He asked who was there."

The *note of exclamation* (!), used after interjections and exclamations; also usually after the Vocative Case—as: "All hail, great master!" "Alas!"

Curved and square brackets, ( ), [ ], used to separate certain words from the rest of the sentence, to add an explanation of a difficult word, etc.

Inverted commas, double "—", or single —', used to mark quotations. When a quotation occurs within a quotation, the inner quotation is generally marked by single inverted commas—as:

"Breathes there the man with soul so dead,
Who never to himself hath said,
'This is my own, my native land'!"

EXERCISE.

Punctuate the following passage from one of Hans Andersen's Fairy Tales:

"A whiptop and a little ball were together in a drawer among some other toys and the top said to the ball shall we not be bridegroom and bride as we live together in the same box but the ball which had a coat of morocco leather and was just as conceited as any fine lady would make no answer to such a proposal next day the little boy came to whom the toys belonged he painted the top red and yellow and hammered a brass nail into it and it looked splendid when the top turned round look at me he cried to the ball what do you say now shall we not be engaged to each other we suit one another so well you jump and I dance no one could be happier than we two should be indeed do you think so replied the little ball perhaps you do not know my papa and mamma were morocco slippers and that I have a Spanish cork inside me yes but I am made of mahogany

said the top and the mayor himself turned me he has a turning lathe of his own and it amuses him greatly can I depend upon that asked the little ball may I never be whipped again if it is not true replied the top."

Correct the punctuation of the following passage, which is altered from one of Thomas Fuller's "Mixt Contemplations on these Times":

"In the year of our Lord, 1606, there happened a sad overflowing of the Severn-sea. On both sides thereof which, some still alive one I hope thankfully remember ? An account, hereof was written to John Stow the industrious chronicler from Dr. Still: then bishop of Bath and Wells and three other gentlemen of credit to insert in his story one passage, wherein I cannot omit! 'Stow's Chronicle' p; 889 Among other things of note it happened that upon the tops of some hills divers, beasts of contrary nature had got up for their safety as dogs. Cats foxes hares conies moles mice; and rats who remained together ? Very peaceably without any manner or sign, of fear of violence one towards another ? How much of man was there, then, in brute creatures. How much of brutishness is there now in men. Is this a time for those ? Who are sinking for the same cause! To quarrel and fall out: I dare add no more: but the words of the Apostle 2 Tim. ii. 7. Consider what ? I say and the Lord give you, understanding, in all things."

STYLE

The main object of our study of the English language is that we may be able to express ourselves clearly in it, whether in writing or in speech. We must aim not only at meaning exactly what we say, but also at saying exactly what we mean. It is not enough to have our own thoughts and ideas perfectly plain to ourselves; for unless we can convey them clearly to other people, mistakes occur, misunderstandings arise, feelings are often wounded unnecessarily, and mischief frequently follows.

Absolute clearness of style is the result of long and careful discipline, but it is a result that will well repay the labour. It can be cultivated better in writing than in speech, because we can revise what we have written, whereas the spoken word is usually forgotten as soon as uttered. We should therefore make it a practice at first to read and re-read everything that we write, looking carefully for any ambiguity or any loophole for misunderstanding. We may be certain that if a thing is not quite clear to the writer of it, the chances are that it will be very far from clear to anyone else.

Perhaps in no matter is this more important than in one where it is as a rule most neglected—*viz.*, that of writing business letters. It would be interesting to know the time that has been lost and the money that has been wasted simply through confusion and clumsiness of expression in the letters of our large business firms. So far from being a matter of theory, to be indulged in merely by pedantic grammarians, the necessity for a clear style is a very practical matter indeed, as thousands of people have too late found out to their cost.

Then, when clearness of expression in writing has been cultivated, clearness of expression in speech will follow as a matter of course. Have you ever noticed the different manner in which the same event will be described by a man of education and by an unlettered person ? The former in a few bold strokes will give you in two minutes a clear impression of what he has seen; the latter, however, will take at least five times as long, owing to his frequent repetitions and his hunting about for words to convey his meaning, and at the close your impression of the event is still dim and hazy.

How Not to Write a Letter. As an example of what has been said above, let us take the following letter, written *first* as it should not be written—but too often, alas! is; and *secondly* as it should be written. There is no exaggeration here; thousands of similar letters are being written every day.

Letter from a young man applying for the post of cashier in a large business house:

[The letters in brackets refer to the notes on the next page].

Dear Sirs, I have read your advertisement for a cashier in the "——— Gazette" of yesterday's date, which (*a*) I have only just seen, and which (*a*) I have great pleasure in applying for, as I feel to have all the necessary (*b*) qualifications which you require (*b*). If you will write to Messrs. White & Co., I have been (*c*) with them three years, before which I was at Brownlove's, Birmingham, where I was for nearly five years under-cashier, as the testimonials from that firm which (*d*) I gave satisfaction to, and which (*d*) I enclose herewith will show. Leaving them through no fault of my own, you (*e*) will see I have had eight years experience and good character, and while (*f*) I have never been a single penny wrong in my accounts, thousands of pounds every week have passed through my hands, not only in wages, but having (*g*) to negotiate delicate matters for the firm which (*h*) needed careful handling. My age is 31 years old (*i*), although I am not married, and I may say I am a non-smoker, but steady in my habits, and know shorthand. I should have liked to have stayed (*k*) on in my present situation for some things; but without (*l*) I will accept a lower salary, the firm is reducing the staff owing to some cause or another (*m*), which (*n*) I do not see my way to do. While (*o*) I should require a salary of £180, I do not want to be excessive, and should be prepared to entertain your offer as a firm (*p*) of first-rate standing in the business world, and that (*q*) you do not under-pay your servants. Had I have (*r*) seen your advertisement sooner, I would have answered it before, as I said at the beginning (*s*), and trust I am not too late now, which (*t*) is the moment I have seen it. Hoping this will merit your favourable attention when you read it, and trusting to hear further from you when I should be delighted to have an interview when and where desired.

Believe (*v*) me, Dear Sirs,
Your obedient servant,
X. Y. Z.

The letter is not entirely ungrammatical, though its grammar is at fault in some places; but it is a fair example of a confused slipshod style, common enough in those who have never trained themselves to think or write clearly. The faults contained in it are almost too many to mention, but let us notice some of them:

a. The first *which* refers to "Gazette" the second to no particular antecedent, but to some word like "situation," which is vaguely in the writer's mind.

b. Having said *necessary*, he has no need to add "which you require." These words are redundant.

c. The subject of this second half of the *if* clause should be *you*, not *I*: "If you will write . . . you will find that I was," etc.

d. Here, again, *which* refers to two different antecedents, *firm* and *testimonials*, thus causing confusion.

e. The writer having begun with a participle, *leaving*, referring to himself, the subject of the main sentence should be "I," not "you." It was not "you" who were leaving, but "I."

f. This is an example of misplaced emphasis. He means "Although thousands of pounds have passed through my hands every week, I have never been a single penny wrong in my accounts."

g. Hopelessly mixed. Where is there a noun with which the participle *having* can agree?

h. What is the antecedent of *which?* Was it the firm or the delicate matters that needed careful handling?

i. *Old* should be omitted. In the rest of this sentence the emphasis is hopelessly wrong; *although* and *but* give a false contrast, and what has a knowledge of shorthand to do with steadiness of habits?

k. Should be "to stay on."

l. Use the conjunction "unless" instead of "without."

m. Say either "some cause or other," or "one cause or another."

n. To what does *which* refer?

o. Wrong emphasis again; see *f* above.

p. Should be "as being that of a firm."

q. The writer makes *that* depend on some verb like "knowing," which he has vaguely in his mind.

r. "Have" should be omitted.

s. He is here needlessly repeating himself, and also irritating the reader, presuming the reader to have read so far, which is doubtful!

t. A relative pronoun should not refer to an adverb, such as *now*.

v. The writer having used two participles, *hoping* and *trusting*, both referring to himself, the subject of the main verb of the sentence should have been "I," not "you" (which is the understood subject of *believe*). He should have said, "I remain," etc.

These are a few of the details in which the letter is wrong. But in addition the sentences are far too long and involved, and the whole method of expression clumsy and cumbersome in the extreme.

Same Letter Re-written. Contrast the above letter with the following version of the same:

Dear Sirs,—I have only just seen your advertisement in the "—— Gazette" of yesterday's date, and hasten to apply for the post of cashier there advertised as vacant. I have been three years with my present employers, Messrs. White & Co., and before that I was under-cashier at Brownlove's, Birmingham, for nearly five years. I enclose herewith testimonials from the latter firm. My present employers kindly allow me to give you their names for reference. I have thus had eight years' experience of the class of work required. Thousands of pounds have passed through my hands every week, and I have often had to negotiate delicate matters of business for the firm. I am 31 years old, unmarried, and of steady habits. I have also a knowledge of shorthand. My present employers are reducing their staff owing to various reasons, but have asked me to stay on in their employ. As, however, they are not prepared to offer me as high a salary as in the past, I have decided to leave. I should require a salary of £180 per annum; but if that is a higher figure than you are prepared to offer, I shall be glad to hear what you propose. I would leave myself largely in your hands in this matter. I shall be pleased to let you have any further information you may require, or to have an interview with you if you so desire. Trusting that my application is not too late,

I remain, dear sirs, etc.

Chief Errors of Style. It is impossible to mention all the errors of style that can be committed, but the following are the most common. A good many of them will be found to have been exemplified in the letter given above.

1. Irrelative Use of Words. Words are often left without any relation whatever. Examples:

"Your guilt is as great or greater than his," where *as* has nothing to which to relate.

"He is not only acquainted, but well versed in English literature," where *acquainted* should be followed by *with*, to bring it into relation with the rest of the sentence.

"Having crossed the stream, the banks on either side fell in," where *having crossed* has no relation to any other word of the sentence. As it stands, it agrees with *banks;* but the banks did not cross the river.

"Alarmed at the appearance of the sky, a terrific peal of thunder shook the house, so that he ran out," where *alarmed* is not related to any other word. Grammatically, it agrees with *peal of thunder*, but it was not the peal of thunder that was alarmed. The subject of the main sentence should, of course, be *he*.

Such errors as these are usually due to forgetfulness or a sudden change of mind on the part of the writer or speaker. In the following sentence, for example, "I would as soon perish in the lowest depths of the sea—yea, die the most degrading death that is possible to man or woman, beast or brute, than I would accept life

on the terms you offer," the writer forgets that he has started with "as soon," and imagines that he has said, "I would *rather* perish." Hence, the use of *than*. There is need of great care to avoid errors like these, especially in long and involved sentences.

2. Wrong Order. Many errors arise from a wrong or misleading *order* of words.

As a rule, a sentence should run in its natural order: Subject (and its limitations), predicate, object (and its limitations), adverbial limitations of the predicate—as: "The dying hero spoke words of consolation and of cheer in the midst of his mortal agony." For the sake of emphasis, or for certain other reasons, the order may be altered. But whatever be the order, the important point is that the meaning shall be clear.

Great care is needed in dealing with relative pronouns, lest they seem to refer to a substantive which is not intended to be their antecedent. For example: "He threw a pint pot at her head, which smashed into a thousand pieces." "Much energy was displayed by Mr. Smith in running down the street after his silk hat, which he felt might have been devoted to a better purpose." The only way of avoiding this pitfall is to place the antecedent *immediately* before the relative—thus: "He threw at her head a pint pot," etc. "Mr. Smith, in running down the street after his silk hat, displayed an amount of energy," etc.

Equal care is necessary in dealing with adverbs or adverbial phrases, as these have an awkward knack of appearing to qualify words which they are not intended to qualify. The following examples are among those given by Dr. Gow in his book, "A Method of English":

"He blew out his brains after bidding his wife good-bye with a gun."

"The Moor seizing a bolster full of rage and jealousy smothers her."

"Erected to the memory of John Phillip accidentally shot as a mark of affection by his brother."

"He was driving away from the church where he had been married in a coach-and-six."

"The young man coloured with pleasure and promised to return in quite a gratified tone of voice."

3. Misplacement of Emphasis. In a complex sentence, errors often arise through misplacement of emphasis. A sentence which ought to be independent and stand alone is sometimes thrown into the form of a subordinate clause. It thereby loses the emphasis that should attach to it. This is especially the case with relative pronouns and adverbs. For example, the full force of "He called me a liar, and then I struck him" is not adequately represented by "He called me a liar, when I struck him." Similarly, with "I have said it, and I will do it," and "I have said it, which I will do."

Two co-ordinate sentences, each of which ought to stand alone, cannot be thrown into the form of a single complex sentence (one of the two becoming a subordinate clause) without loss of meaning. Thus, "Ink, having a bitter taste, makes a mark on paper" is not a good substitute for "Ink has a bitter taste: it also makes a mark on paper"; for its making a mark on paper is not a consequence of its having a bitter taste.

For clearness of style and simplicity of language the Authorised Version of the English Bible is hard to beat. Next to that, perhaps, a study of Ruskin's writings will give one an idea of beauty and simplicity of style. Let a man read nothing but these for three months, and he will find his style growing simpler and clearer, and at the same time more dignified. When he is well saturated with their spirit, he can turn without harm to exponents of other styles. He can read Carlyle without falling into his faults, and can pass unscathed through the most flowery and ornate sentences of the late Dean Farrar. But each man has a style of his own for which he is adapted by nature. Therefore let his study of the great stylists be rather for the perfecting of his own particular gift than with the idea of slavishly imitating another's.

READING ALOUD

Reading aloud seems to be almost a forgotten art. Our grandfathers and grandmothers were adepts at it; but as it is a process that takes some time, it does not appeal to the present generation. Even our public readers, such as the clergy and ministers of all denominations, seem to think that anything will do in this connection. With few exceptions, the occupiers of our pulpits are utterly incompetent readers. It is, however, an art that is well worth cultivating. It can give great pleasure, it can become one of the most potent educational agencies in the world, and—to put it on its lowest level—it may help one very materially to benefit his position in life.

Clearness is here, as in style, the main object. We need first to grasp the writer's meaning, and then to convey that meaning as adequately as possible to others. Hurry is fatal to reading aloud. A passage that is gabbled over loses its intelligibility for the hearers. Emphasis is also a most important point, a whole passage being often "murdered" by a mistake in this respect. Finally, we must strive to avoid monotony; nothing is more dreary than to listen to a reader who ends every sentence in exactly the same key. If anyone wants an agonising example of this, let him listen to a bad reader reading one of the longest psalms in the Psalter. The inflection of the voice should be carefully studied, so as to give as much variety and life as possible to the subject-matter.

Value of Emphasis. Most people when asked if they can read aloud will promptly answer "Yes." Let us take warning from the fate of a young American student in the theological seminary at Andover. History relates that he had an excellent opinion of his own talent in elocution, and that he once asked his professor, "What do I specially need to learn in this department?"

"You ought just to learn to read," said the professor.

"Oh, I can read now!" replied the student.

The professor handed him a New Testament, and asked him to read St. Luke xxiv. 25. The student read, "Then he said unto them, O fools, and slow of heart to *believe* all that the prophets have spoken."

"Ah," said the professor, "they were fools for *believing* the prophets, were they?"

That was not right; so the young man tried again.

"O fools, and slow of heart to believe *all* that the prophets have spoken."

"The prophets then were sometimes liars?" asked the professor.

"No. O fools, and slow of heart to believe all that the *prophets* have spoken."

"According to this reading," the professor suggested, "the prophets were notorious liars."

This was not a satisfactory conclusion; and so another trial was made.

"O fools, and slow of heart to believe all that the prophets have *spoken*."

"I see now," said the professor; "the prophets wrote the truth, but they *spoke falsehoods*."

[Quoted by W. H. Groser in his "Teacher's Manual."]

Surely it is worth an effort to become good readers. Ten minutes a day spent in careful deliberate reading aloud would soon make a great difference in the delivery of the average person.

Continued

FRENCH

Continued from page 1448

By Louis A. Barbé, B.A.

DEMONSTRATIVE ADJECTIVES

The demonstrative adjectives are: *ce, cet, cette,* this or that; *ces,* these or those.

CE, this, that, is used before a masculine singular noun, beginning with a consonant or aspirated *h*: *ce village,* this village; *ce hameau,* that hamlet.

CET, this, that, is used before a masculine singular noun beginning with a vowel or silent *h*: *cet arbre,* this tree; *cet habit,* that coat.

CETTE, this, that, is used before any feminine singular noun: *cette pelouse,* this lawn; *cette auberge,* that inn; *cette herbe,* that grass; *cette harpe,* that harp.

CES, these, those, is used before all plural nouns: *ces villages, ces hameaux, ces arbres, ces habits, ces pelouses, ces auberges.*

There may be qualifying adjectives between the demonstrative and the noun: *ce petit village, ce grand arbre, cette vieille maison, ces belles fleurs.*

Of themselves, the demonstrative adjectives mean both "this" and "that," in the singular, and both "these" and "those" in the plural.

When it is required to distinguish between nearer and more remote objects, *ci* (= *ici*, here), and *là* (there), are respectively placed after the noun, and joined to it by a hyphen: *ce bijou-ci est plus précieux que ce bijou-là,* this jewel is more valuable than that jewel; *ces tableaux-ci sont plus beaux que ces tableaux-là,* these pictures are finer than those pictures.

POSSESSIVE ADJECTIVES

1. The possessive adjectives are:

	Masculine	Feminine.	Plural.
My	*mon*	*ma*	*mes*
Thy	*ton*	*ta*	*tes*
His and Her	*son*	*sa*	*ses*
Our	*notre*	*notre*	*nos*
Your	*votre*	*votre*	*vos*
Their	*leur*	*leur*	*leurs*

2. Possessives agree, not with the possessor, as in English, but with that which is possessed, thus: *mon père,* my father; *ma mère,* my mother; *mes enfants,* my children. Consequently, *son père,* means both his father and her father; *sa mère,* his mother and her mother; *ses enfants,* his children and her children.

3. *Mon, ton, son* are not always masculine. They are also used instead of *ma, ta, sa* before feminine words beginning with a vowel or silent *h*, thus: *ignorance, erreur,* and *histoire* are feminine, but we say *mon ignorance, ton erreur, son histoire.*

4. When, from the other words in the sentence, there can be no doubt as to the possessor, the definitive article is used instead of the possessive pronoun. This is particularly the case with regard to parts of the body: *J'ai mal à la tête,* I have a headache; *liez-lui les mains derrière le dos,* tie his hands (*lit.* to him the hands) behind his (the) back.

5. The use of the definite article instead of the possessive adjective is very general in descriptions of personal appearance. Possession is then expressed by means of the verb *avoir*: His hair is black, *il a les cheveux noirs;* her eyes are blue, *Elle a les yeux bleus.*

EXERCISE X

1. There are no large houses in that village.
2. Those large trees are oaks (*chênes*).
3. These children are the sons of that barrister.
4. This house is older than that house.
5. That child is the most industrious (*appliqué*), pupil in the class.
6. Have you spoken to that gentleman and to those ladies?
7. Why (*pourquoi*) have you put (*mis*) my books on that table?
8. Your brother has bought those horses.
9. This little boy and that little girl are very amiable.
10. I have not yet (*encore*) read (*lu*) those papers (*journal*).
11. When (*quand*) those children are well-behaved (*sage*) their mother is happy (*heureux*).
12. Our parents are our best friends.
13. That young lady has black hair and blue eyes.
14. The boy speaks to his mother, and his sister speaks to her father.

COMPOUND TENSES

The past indefinite (*passé indéfini*) of verbs (usually called perfect in English) is formed by adding the past participle (*participe passé*) to the present indicative of *avoir*, to have.

The past participle of *avoir* is *eu*.

The past participle of *être* is *été*.

The past participle of verbs of the first conjugation (verbs ending in *er* in the infinitive) always ends in *é*, thus: *aimer*, to love, *aimé*, loved; *donner*, to give, *donné*, given.

Tenses which, like the past indefinite, consist of an auxiliary and a past participle, are called compound tenses.

Past Indefinite of AVOIR:	Past Indefinite of ÊTRE:
I have had, etc.	I have been, etc.
j'ai eu	*j'ai été*
tu as eu	*tu as été*
il a eu	*il a été*
elle a eu	*elle a été*
nous avons eu	*nous avons été*
vous avez eu	*vous avez été*
ils ont eu	*ils ont été*
elles ont eu	*elles ont été*

Past Indefinite of AIMER:

I have loved, etc.
j'ai aimé
tu as aimé
il a aimé
elle a aimé
nous avons aimé
vous avez aimé
ils ont aimé
elles ont aimé

In compound tenses in which *avoir* is the auxiliary verb, the past participle does not agree with the subject.

In compound tenses the negation is formed by putting *ne* (*n'*) between the subject and the auxiliary, and *pas* between the auxiliary and the past participle.

Past Indefinite Conjugated Negatively:

AVOIR.	ÊTRE.
I have not had, etc.	I have not been, etc.
je n'ai pas eu	*je n'ai pas été*
tu n'as pas eu	*tu n'as pas été*
il n'a pas eu	*il n'a pas été*
elle n'a pas eu	*elle n'a pas été*
nous n'avons pas eu	*nous n'avons pas été*
vous n'avez pas eu	*vous n'avez pas été*
ils n'ont pas eu	*ils n'ont pas été*
elles n'ont pas eu	*elles n'ont pas été*

AIMER.

I have not loved.
je n'ai pas aimé
tu n'as pas aimé
il n'a pas aimé
elle n'a pas aimé
nous n'avons pas aimé
vous n'avez pas aimé
ils n'ont pas aimé
elles n'ont pas aimé

NEGATIVE EXPRESSIONS

The expressions with which a verb may be conjugated negatively are:

ne . . . *pas*, not
ne . . . *point*, not (stronger than *ne* . . . *pas*)
ne . . . *que*, only, nothing but
ne . . . *plus*, no more, no longer
ne . . . *jamais*, never
ne . . . *guère*, not much, hardly
ne . . . *personne*, nobody
ne . . . *rien*, nothing

Thus:

Il n'a pas de livres, he has no books.
Il n'a pas eu de peine, he has had no trouble.
Il n'a point d'argent, he has no money at all.
Il n'a plus parlé, he spoke no more.
Il ne parle guère, he does not speak much.
Il ne lit jamais, he never reads.
Il n'a jamais lu, he has never read.

When "nobody" and "nothing" are the objects of a verb, *ne* precedes the verb and *personne* or *rien* follows it:

je ne vois personne, I see nobody.

But, with compound tenses, whilst *rien* comes between the auxiliary and the past participle, according to rule, *personne* comes after both auxiliary and past participle:

je n'ai rien vu, I have seen nothing.
je n'ai vu personne, I have seen nobody.

When "nobody" and "nothing" are subjects of a verb, their place is before both *ne* and the verb:

personne ne parle, nobody speaks.
rien n'empêche, nothing prevents.

When any of these negations are used without a verb there is no *ne*: Who has spoken? Nobody. *Qui a parlé? Personne.*

In *ne* . . . *que*, the *que* comes after the verb in both simple and compound tenses:

Je ne vois que votre frère, I see only your brother; *je n'ai vu que votre frère*, I have seen only your brother. *Ne* . . . *que* does not prevent the use of the article as well as *de* to express the partitive meaning, as do the other negatives: *je n'ai vu que des arbres*, I have seen nothing but trees.

NOTE. In the following exercise special attention must be paid to the use of the definite and of the partitive articles, as explained in the earlier lessons.

EXERCISE XI
RECAPITULATORY

une amande, almond
un âne, ass
un animal, animal
le bœuf, ox
le bois, wood
le chacal, jackal
le champ, field
la chèvre, goat
le chien, dog
le corps, body
un écureuil, squirrel
une espèce, species, kind
une étoile, star
un être, being
le gland, acorn
une histoire, history
un intérieur, interior
le lièvre, the hare
le lion, the lion
le loup, wolf
le minéral, mineral
le métal, metal
la noisette, hazel-nut
un oiseau, bird
une oreille, ear
la plante, plant
le poil, hair (of animals)
le règne, kingdom (of Nature)
le renard, fox
le tigre, tiger
la variété, variety
le végétal, vegetable

agile, active
ardent, mettlesome, spirited
bon, good, kind, gentle
capricieux, capricious, frisky
courageux, courageous
court, short
cruel, cruel
docile, docile
domestique, domestic
féroce, ferocious, savage
fier, proud
fort, strong
fougueux, fiery
impétueux, impetuous
intéressant, interesting
léger, light, swift
long, long
naturel, natural
nerveux, vigorous
nombreux, numerous
nuisible, injurious, hurtful
patient, patient
robuste, hardy
rude, rough, coarse
sauvage, wild
sobre, temperate
timide, timid
tranquille, quiet
vagabond, fond of wandering
végétal, vegetable
vif, quick
vivant, living

composer, to compose
étudier, to study
manger, to eat
semer, to scatter
passer, to pass

comme, as, like
extrêmement, exceedingly
fort, very
très, very
ou, or

Natural history studies plants, minerals and animals. Plants or vegetables compose the vegetable kingdom. Plants are scattered on the earth like stars in the heavens. Minerals are bodies in the interior of the earth. Metals are minerals. In the natural history of animals an infinite variety of living beings pass before our eyes. The species of animals are more numerous than the species of plants. The animals the most useful to men are domestic animals. Amongst the domestic animals are horses, asses, oxen, cows, sheep and goats. Horses are proud and spirited, but they are as docile as courageous. Horses are more elegant than asses and than oxen. Their ears are less long than the ears of asses. They are not so short as the ears of oxen. There are wild horses. They are stronger, swifter, more vigorous than domestic horses, but they are less useful. Asses are gentle, temperate, and useful. They are as patient and as quiet as horses are proud, fiery and impetuous. Dogs also are domestic animals. There are wild dogs, but they are savage. They are as savage as wolves and as jackals. Goats are not so useful to men as sheep, but they are very useful. Their hair is rougher than the wool of sheep. They are stronger, lighter, more active than sheep. They are lively, hardy, frisky, and fond of wandering. Amongst wild animals, lions and tigers are the most savage and the most cruel. Foxes are wild also, but they are not so savage as tigers. They are less savage than jackals. Hares are wild, but they are not hurtful. They are exceedingly timid. Squirrels also are very timid little animals. They are very pretty and very interesting. They eat fruits, almonds, walnuts and acorns. There are no squirrels in the fields. They are in the woods on trees, like birds.

Key to Exercise VIII. [page 1446]

1. La sœur du jeune homme a de gentils petits enfants.
2. Les vieilles maisons ont de grands jardins.
3. Le mois de décembre est le dernier mois de l'année.
4. Il a acheté un vilain gros chien la semaine dernière.
5. Ils demeurent dans une grande maison blanche près du château ruiné.
6. Il y a deux tables rondes dans la petite chambre carrée.
7. Avez-vous de l'encre rouge ?
8. Non, mais j'ai de l'encre noire et de l'encre bleue.
9. La langue française est une langue romane.
10. L'Espagne est un pays catholique ; l'Angleterre et l'Écosse sont des pays protestants.
11. L'enfant prit l'argent d'une main tremblante.
12. La vieille église est près du parc public.
13. Le pasteur français est un homme très intelligent et très instruit.
14. Il n'y a pas de remèdes infaillibles.
15. Un brave homme n'est pas toujours un homme brave.
16. Un homme riche peut être un pauvre homme.
17. Un fossé large et profond défend l'approche du vieux château.
18. Paris est une grande et belle ville.
19. Ils ont rencontré des difficultés insurmontables.
20. Nous avons parlé à un jeune homme très aimable.

Key to Exercise IX. [page 1447]

1. Le cheval est plus grand que l'âne, aussi grand que le bœuf et moins grand que l'éléphant.
2. Les chats ne sont pas si fidèles que les chiens.
3. Le tigre est le plus féroce des animaux.
4. Mes plus beaux tableaux et mes meilleurs livres ne sont pas ici.
5. Voici le mieux connu des romans de Dumas.
6. Il demeure dans la plus petite maison du village.
7. La moindre difficulté décourage les élèves paresseux.
8. Il a passé plus de trois mois en France.
9. Trois chats mangent moins que deux chiens.
10. Le loup a mangé plus de trois brebis.
11. L'or est moins utile que le fer ; l'or est le plus précieux, mais le fer est le plus utile des métaux.
12. La montagne la plus élevée de l'Écosse a plus de quatre mille pieds.
13. Voilà un des élèves les plus intelligents de la classe.
14. La plus jolie des deux sœurs n'est pas la plus aimable.
15. Les fruits les plus amers sont souvent les plus sains.
16. Le remède est souvent pire que le mal.
17. Les médecins sont plus utiles que les avocats.
18. On a souvent besoin d'un plus petit que soi.

Continued

 Continued from page 1317

By José Plá Cárceles, B.A.

All Spanish verbs, as we have already noted, are limited to three conjugations, which are distinguished thus: verbs ending in *ar* belong to the first conjugation, those ending in *er* to the second, and those ending in *ir* to the third. That part of the infinitive which precedes these terminations is called the stem.

Verbs. Verbs may be *regular* or *irregular*, *personal* or *impersonal*, *active* or *neuter*, and *reflective*. *Regular* verbs are those which in their conjugation follow the rules laid down for the model verb of their termination; *irregular* verbs, therefore, are those which deviate from the regular form. *Impersonal* verbs are those verbs which can only be conjugated in the third person; *active* verbs those which express an action transmissible to another person or object; *neuter* verbs, on the contrary, express an action or state that cannot be transmitted; and a verb is called *reflective* when the subject is at the same time the object to whom the action is transmitted.

We now consider the present indicative of each conjugation of the *regular verbs*.

First Conjugation. [Termination AR.] The present indicative of all regular verbs of the first conjugation is obtained by adding the terminations *o, as, a, amos, ais, an* to the stem. *Comprar*, to buy, may be taken as a model for the first conjugation.

PRESENT INDICATIVE OF *Comprar*

Singular	*Plural*
Compr-o, I buy	*Compr-amos*, we buy
Compr-as, thou buyest	*Compr-ais*, you buy
Compr-a, he, she buys you buy	*Compr-an*, they, you buy

Questions are formed in Spanish simply by putting the subject after the verb, and negative sentences by placing the adverb *no* in front of the verb. The English auxiliary verb "to do" is never translated.

EXERCISE XV

To use	*Usar*	To employ	*Emplear*
To advise	*Avisar*	To sign	*Firmar*
To draw	*Girar*	To take	*Tomar*
To travel	*Viajar*	To accept	*Aceptar*
To work	*Trabajar*	At sight	*A la vista*
Secretary	*Secretario*	The hour	*La hora*
Tea	*Té*	Terms	*Condiciones*
Coffee	*Café*	Daily	*Diariamente*
Winter	*Invierno*	The milk	*La leche*
Thank you	*Gracias*		

1. I use large envelopes. 2. My friend employs two servants. 3. We do not advise (to) our customers. 4. Does the secretary sign all (the) cheques? 5. They do not draw at sight. 6. Do all the clerks speak Spanish? 7. He does not travel in winter. 8. They do not accept our terms. 9. Do they work many hours daily? 10. Do you take tea or coffee? 11. I take coffee with milk, thank you.

Second Conjugation. [Termination ER.] The present indicative of all regular verbs of the second conjugation is formed by adding to the stem the terminations *o, es, e, emos, eis, en*. *Beber*, to drink, is a model for this conjugation.

PRESENT INDICATIVE OF *Beber*

Singular	*Plural*
beb-o, I drink	*beb-emos*, we drink
beb-es, thou drinkest	*beb-eis*, you drink
beb-e, he, she drinks, you drink	*beb-en*, they, you drink

EXERCISE XVI

To learn	*Aprender*	To believe	*Creer*
To run	*Correr*	To answer	*Responder*
To eat	*Comer*	To fear	*Temer*
To sell	*Vender*	To owe	*Deber*
To promise	*Prometer*	Fast	*De prisa*
Foreign	*Extranjero*	The quarter	*El trimestre*
The language	*El idioma*	To understand	*Comprender*
Shopkeeper	*Tendero*	Explanation	*Explicación*
The consequences	*Las consecuencias*		

1. He learns foreign languages. 2. That horse runs very fast. 3. Do you eat much bread? 4. The shopkeeper does not sell much now. 5. Do they not understand your explanation? 6. I believe they are not English. 7. Why do they not answer? 8. Because they fear the consequences. 9. I do not promise that. 10. We owe three quarters.

Third Conjugation. [Termination IR.] The present indicative of all regular verbs of the third conjugation is formed by adding to the stem the terminations *o, es, e, imos, is, en*. *Cumplir*, to fulfil, may be taken as a model for the third conjugation.

PRESENT INDICATIVE OF *Cumplir*

Singular	*Plural*
cumpl-o, I fulfil	*cumpl-imos*, we fulfil
cumpl-es, thou fulfillest	*cumpl-is*, you fulfil
cumpl-e, he, she fulfils, you fulfil	*cumpl-en*, they, you fulfil

EXERCISE XVII

To live	*Vivir*	To admit	*Admitir*
To receive	*Recibir*	To discuss	*Discutir*
To go up	*Subir*	To decide	*Decidir*
To attend	*Asistir*	To supply	*Surtir*
Seldom	*Raramente*	The price	*El precio*
Spring	*Primavera*	Promises	*Promesas*
Several	*Varias*	Money	*Dinero*
The firm	*La casa*	European	*Europeo*
To distribute	*Repartir*	The meeting	*La reunión*
Every week	*Todas las semanas*		

1. He does not live here now. 2. Do you receive news from America every week? 3. Why do they not admit children? 4. We do not discuss that. 5. The prices very seldom go up in the spring. 6. What do you decide? 7. She never fulfils her promises. 8. Who distributes the money? 9. We supply several

European firms. 10. I do not attend (to) all their meetings.

Reading Exercise

Artículos de la Constitución Mejicana

Artículo 30. Son mejicanos: (1) Todos los nacidos, dentro ó fuera del territorio de la República, de padres mejicanos. (2) Los extranjeros que se naturalicen conforme á las leyes de la Federación. (3) Los extranjeros que adquieran bienes raíces en la República, ó tengan hijos mejicanos, siempre que no manifiesten resolución de conservar su nacionalidad.

Artículo 31. Es obligación de todo mejicano: (1) Defender la independencia, el territorio, el honor, los derechos é intereses de su patria. (2) Contribuir á los gastos públicos, así de la Federación como del Estado y municipio en que resida, de la manera proporcional y equitativa que dispongan las leyes.

Artículo 32. Los mejicanos serán preferidos á los extranjeros, en igualdad de circunstancias, para todos los empleos, cargos ó comisiones de nombramiento de las autoridades, en que no sea indispensable la calidad de ciudadano. Se expedirán leyes para mejorar las condiciones de los mejicanos laboriosos, premiando á los que se distingan en cualquier ciencia ó arte, estimulando al trabajo y fundando colegios y escuelas prácticas de artes y oficios.

Artículo 33. Son extranjeros los que no posean las calidades determinadas en el artículo 30. Tienen derecho á las garantías otorgadas en la sección correspondiente de la presente Constitución, salva en todo caso la facultad que el Gobierno tiene para expeler al extranjero pernicioso. Tienen obligación de contribuir á los gastos públicos, de la manera que dispongan las leyes, y de obedecer y respetar las instituciones, leyes y autoridades del país, sujetándose á los fallos y sentencias de los tribunales, sin poder intentar otros recursos que los que las leyes conceden á los mejicanos.

Translation of Reading Exercise

Articles of the Mexican Constitution

Article 30. Mexicans are: (1) All those born within or without the Republic, of Mexican parents. (2) Foreigners naturalised in conformity with the laws of the Federation. (3) Foreigners who acquire real estate in the Republic, or have Mexican children, if they do not declare their intention to retain their nationality of origin.

Article 31. It is the duty of every Mexican: (1) To defend the independence, the territory, the honour, the rights and interests of his country. (2) To contribute, in the proportional and equitable manner provided by law, to meet the public expenses of the Federation, the State, and the municipality in which he resides.

Article 32. Mexicans shall be preferred under equal circumstances to foreigners, for all public employments, charges, or commissions, when the citizenship is not indispensable. Laws shall be enacted to improve the conditions of industrious Mexicans, by rewarding those who distinguish themselves in any science or art, promoting labour, and founding colleges and manual training schools.

Article 33. Foreigners are those who do not possess the qualifications determined in the Article 30. They have a right to the guarantees established by the corresponding section of the present Constitution, except that in all cases the Government has the right to expel pernicious foreigners. They are under obligation to contribute to the public expenses in the manner which the laws may provide, and to obey and respect the institutions, laws, and authorities of the country, subjecting themselves to the decisions of the tribunals, without power to seek other protection than that which the laws concede to Mexican citizens.

Key to Exercise XI

1. (Ella) está cantando. 2. Están andando. 3. Estamos corriendo. 4. Están vendiendo. 5. Estoy aprendiendo español. 6. Está tronando. 7. ¿ Está Vd escribiendo una carta á mi amigo ? 8. ¿ Donde están viviendo ahora ? 9. Está abriendo la puerta. 10. Estamos firmando el documento. 11. (Ella) está comprando un sombrero. 12. Estoy bebiendo un vaso de leche. 13. Está lloviendo. 14. Están imprimiendo un libro.

Key to Exercise XII

1. (Ella) ha cambiado su dinero. 2. (Ellas) han arreglado los papeles. 3. Su socio ha rechazado la oferta. 4. ¿ Ha preguntado Vd su nombre ? 5. No hemos ofrecido géneros nuevos este año. 6. Los fabricantes han concedido una bonificación á sus clientes. 7. No he leido el informe todavia. 8. Mi amigo ha perdido su destino. 9. ¿ Han recibido Vds los giros del banco ? 10. (Nosotras) hemos pedido detalles de la oferta. 11. El empleado ha ido al correo. 12. Su mensajero (de Vd) ha venido tarde esta mañana.

Key to Exercise XIII

1. ¿ Quien está ahí ? 2. Soy yo. 3. ¿ Quienes fueron al teatro anoche ? 4. Ese es el comerciante, cuyo telegrama hemos recibido esta mañana. 5. ¿ De quien es este lápiz ? 6. ¿ á quien ha hablado Vd en la escalera ? 7. ¿ Para quien es esa factura ? 8. El hombre que hemos visto en la calle es el jefe de la oficina. 9. Nosotros somos los que hemos cambiado el billete de banco. 10. ¿ Es Vd quien ha llamado á la puerta? 11. No; el hombre que ha llamado está abajo. 12. ¿ Con quien ha cenado Vd ? 13. No he cenado todavia; no he tenido tiempo; he estado ocupado toda la mañana. 14. ¿ Quien está fumando en la sala ? 15. Los hombres que han traido los baules.

Key to Exercise XIV

1. ¿ Cuál diccionario ? 2. ¿ Qué giros ? 3. El ha enviado dos cheques firmados los cuales no he recibido. 4. ¿ Cuál ha traido Vd ? 5. He escrito el informe que he prometido. 6. Yo no sé cuales tiene. 7. No ha telegrafiado todavía, lo cual es muy extraño. 8. Hemos pedido diez cajas, las cuales no han llegado todavía. 9. He comunicado las noticias al cajero, el cual ha comprobado las cuentas en el acto. 10. ¡ Qué respuesta ! 11. ¡ Qué lindo !

Continued

The "Skeleton" and "Forward" Bastes. Important Points in Fitting a Garment. Errors and Alterations. Waterproofing.

TRYING ON AND FITTING

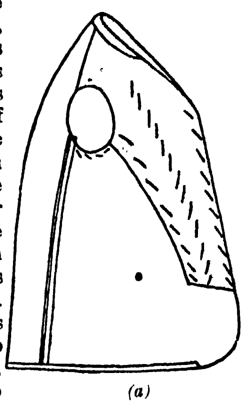
There are several methods of preparing a garment for trying on, but as a rule one of two styles is resorted to. These are known as the "skeleton" baste [25a] and the "forward" baste [25b].

In the former the various seams are basted together, the canvas is put in the fore parts, one sleeve basted in, and sometimes a piece of canvas is put on to do duty for the collar. This plan is very defective, as it does not convey, either to the cutter or the customer's mind, any proper idea of what the garment will be like when finished. No seams are sewn, no manipulation is done, and no linings are in.

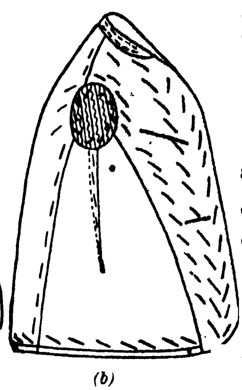
In the latter style the shoulders and fronts are both worked up, the seams are sewn with the exception of the back or the under-arm seam, the shoulders and the scye, the first row of sewing is put in, the edge and the linings are basted over, both sleeves basted in, and the collar basted on but not covered. This necessitates more work being put into the garment before it can be tried on, but as it is nearly all work that stands, it is not labour wasted.

Fitting. The first thing to note in trying on a garment is that it is properly on. This requires some little care; owing to the scye seams not being opened the armhole is smaller than it will be when finished. The garment being properly on, the first thing to note is the balance. If it hangs away at the back, it is too long in the front. If it stands away in the front it is too short in the front. If the balance is not correct, rip shoulder seams and adjust it to the customer's needs, then proceed to pin the fronts together and note the size. Place the two front edges together, and pin it up as shown on Fig. 28, and then proceed to note the various points in the following order:

1. The top of back, including the height of collar. 2. The back scye, including the top of side-seam. 3. The waist at back and sides. 4. The bottom of the back and sides. [Points 1 to 4 are illustrated on 26] 5. The balance of the sleeve. 6. The width of the sleeve at the elbow and cuff. 7. The length of the sleeve. [Points 5 to 7 are indicated on 27] 8. The shoulder and front of scye. 9. The height of buttoning and the lapel. 10. The waist at front. 11. The bottom of the front [28].



(a)



(b)

25. "SKELETON" AND "FORWARD" BASTE

Having noted these points, find out your customer's ideas on the various points and arrange for finish.

Alterations. Alterations are never attractive, but if customers are to be consulted, then alterations are sure to occur. They arise from errors in size and shape.

Errors in Size. A garment may be either too long or too short, too wide or too narrow. In shortening jackets, trousers, etc., the alteration must be done at the bottom, otherwise it will affect the depth of scye and, in the former case, the natural waist length, and, in the latter, the body rise. In dealing with sleeves it may be desirable sometimes to shorten equally at top and bottom in order to avoid getting the elbow too low.

In lengthening there is generally only one place to do it, that is where the inlay has been left. There are, however, one or two artifices that are helpful with certain garments. For instance, sleeves may be lengthened by putting on cuffs, and vests by putting in new backs. The body rise of trousers may be lengthened by dropping the fork and making up the length of leg by the inlay at the bottom. In increasing or reducing the width of a garment that is made up, it is generally done at the under-arm seam, adjusting the armhole as far as possible; and if the alteration is only a moderate one it answers fairly well. If, however, the alteration is extreme it will be necessary to adjust the neck point, otherwise the alteration will be too local.

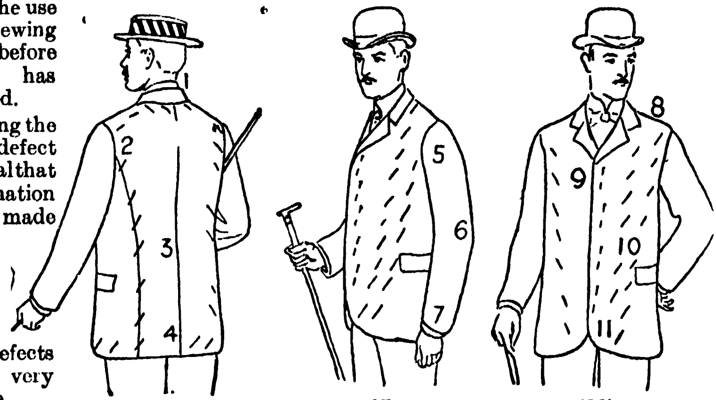
Errors in Shape. The total length and width of a garment may be correct, but the size may not be properly distributed, thus there may be too much room in the back, and too little in the front, and vice versâ. These defects show themselves in folds and creases.

Folds indicate an excess of material in the reverse way to which they run, thus horizontal folds indicate excess of length perpendicularly. Perpendicular folds are the result of excess of width horizontally. Creases, on the other hand, are the result of a lack of material in the direction in which they run—as, for instance, creases from neck point to front of scye, which are caused by a shortness at the neck point, which must be lengthened. Fulness, or loose material, is generally due to a tightness at some surrounding

part, as in the case of fulness at the top of side seam in lounges, which is frequently caused by too much suppression taken out of the waist.

Twisted seams are caused by the upper and lower layers of the material not being put together fairly, the one being kept tight whilst the other is fulled on; this result is often brought about by the use of the sewing machine before the seam has been basted.

In deciding the cause of a defect it is essential that an examination should be made of the surrounding parts, as different causes produce defects that are very much alike.



(26) (27) (28)

26–28. FITTING COAT

If it is a case of tightness, note the direction of the strain. If folds, observe the way they run. If fulness, examine for tightness of surrounding parts. If twist, observe the direction of the twist.

TIGHT SCYE. If arising from lack of room from centre of back, let out at under-arm seam. If caused by shortness from nape of neck to bottom of scye, let out shoulder point or deepen scye. It may also need a larger sleeve.

FULNESS AT TOP OF SIDE SEAM. If produced by a too long back, pass back up at shoulders and neck. If by badly put in sleeves, rip out the sleeve at that part, draw in the back scye, and keep the sleeve in close, disposing of any fulness there may be right at the bottom of the scye. If by too much hollow at waist, let out side seam at that part. If by tightness over the seat, let out at that part. If by too short a collar, lengthen the collar or put on a new one.

FULNESS AT FRONT OF SCYE. Crooken the shoulder and take a V out at front of gorge.

CREASES ACROSS THE FOREARM OF SLEEVE. Lower forearm, or raise the front pitch and lower the hind arm pitch.

TIGHTNESS ON TOP BUTTON. Crooken the shoulder, and, if necessary, let out under-arm.

FULNESS AT TOP BUTTON. Straighten the shoulder and, if necessary, take in under the arm.

FULNESS AT FORK OF TROUSERS. Reduce width at bottom of fly seam, and take in at top of leg seam.

STRAIN FROM FORK TO KNEE. Let out at top of leg seam and, if possible, crooken the seat seam.

HORSESHOE FOLDS IN TROUSERS. Rip side seam and leg seam, and keep under side on tight at both leg and side seams for 10 in. or 12 in. down from fork, and full on a corresponding amount over the calf.

Waterproofing. Many garments are now made up from shower-proof cloth. It is common with tailors to send the garment to be waterproofed after the seams are sewn, etc., but before it is finished. There is no doubt this plan is much better than the old styles of macintosh, which were not only cold and uncomfortable but very unhealthy. The perfect ventilating qualities and the superior appearance of the waterproofed cloth give it a great advantage.

As a general rule, tailors send the garment to the wholesale woollen warehouse to have it waterproofed as far forward in the making up as possible; and as this is invariably done and returned within two days, they seldom trouble to do it themselves, especially as the charge made is very low. Still, it may be advantageous to be able to do this, and so we will describe the process. Dissolve a quarter of a pound of powdered alum, and rather more than a quarter of a pound of sugar of lead, in three gallons of clean water, stirring it twice daily for two days; then, when it has become quite clear, pour it off and add to the clear liquid two drams of isinglass which has been previously dissolved in warm water. Ensure this being thoroughly mixed, and then steep the garment in it for five or six hours, after which hang it up to drain and dry it carefully, avoiding wringing. Garments treated in this way are shower-proof, and will keep out a considerable quantity of rain.

How to Test Cloth. If cotton is suspected, the simplest plan is to dissolve all the wool; this may easily be done by putting a piece of the material into a solution of caustic potash and letting it boil for a short time. If the reverse operation is desired—*i.e.*, to destroy the cotton—it may be done in this manner: Soak it in dilute sulphuric acid standing at 4° Baume, for half an hour, then take it out, rinse, wring, and dry it in a place where the temperature is 180° to 200° F.

If it is desired to remove silk, it may be slowly dissolved by concentrated zinc chloride made neutral by boiling with zinc oxides. These are a few things out of many in which the chemist can help the tailor.

TAILORING CONCLUDED

The Sources, Properties, Recovery, and Industrial Uses of Tin and Zinc. Tin-plates. The Processes of Tinning and Galvanising.

TIN AND ZINC

TIN

Tin, the symbol of which is Sn, and the atomic weight 117·35, was one of the metals familiar to and used by primitive man. Bronze is an alloy of tin and copper, and bronzes have been recovered from the ruins of ancient Nineveh and other sites which were peopled back in the dawn of recorded history.

Properties of Tin. The colour of metallic tin is silver white, with a lustre that increases with the temperature at which it has been poured. The crystalline structure of tin is the cause of the "cry" of tin—that is, when a piece of tin is bent, the crystals grind against each other, and occasion the peculiar sound so designated. Commercial tin has a specific gravity of 7·5, purer tin being slightly lower. At low temperatures tin is very ductile—its point of maximum ductility being at about the boiling point of water—and can be beaten and rolled into foil, but at 200° C. it is extremely friable and can be powdered. Though ductile, it has little tenacity. Its exact melting point is uncertain, but is about 228° C., its boiling point is between 1,600° and 1,800° C., and at this temperature it burns in the air, thereby forming stannic oxide. Its thermal conductivity is about 150 (silver = 1,000), and its electrical conductivity at 21° C. is slightly over 11 (silver = 100).

Occurrence of Tin. The localities favoured by deposits of tin are not numerous. The mineral never occurs in the native state and only in a few chemical combinations. The most common ore is *cassiterite* or *tinstone*, a dioxide of tin (SnO_2). The tinstone found in Cornwall contains also sulphide of copper, wolfram, pyrites and other minerals. It is in the form of veins usually in plutonic or metamorphic rocks. Alluvial tin, washed from these rocks by denudation, is known as "stream tin," and possesses a high degree of purity. The British deposits of "stream tin" are nearly exhausted. The world's chief sources of tin are Cornwall, in England, and the Malay Peninsula. Less valuable deposits occur in Spain, Bohemia, Sweden, Australia, Africa, and Bolivia. The North American continent, so rich in other minerals, seems to have been very sparingly dowered with deposits of tin.

Alluvial Tin. As with gold, the first tin-workers confined their attention to alluvial deposits, which have been formed by the disintegration of portions of the stanniferous granite masses—the disintegrated portions being carried away after denudation and deposited in the lower valleys and river beds. The alluvial deposits in the Malay Peninsula are worked chiefly by the open-cast method, although in some cases hydraulic mining [see MINING] is practised, and in exceptional instances shaft work is undertaken. They show up to 60 lb. of "black tin" or tinstone—which contains from 65 per cent. to 75 per cent. metallic tin—per cubic yard of gravel. The tin *wash*, as it is termed, is found from 2 ft. to 30 ft. under beds of clay and sand, and varies in thickness from a few inches up to 15 ft. or 16 ft. The "wash" consists of gravel worn smooth in its descent from the parent masses, and carries tin ore up to 30 per cent. of its weight. The Malay tin-miners are Chinese, and their tools and methods are primitive. The wash, as the name implies, carries much water, and after the overburden has been removed, the men work in swamps, which are drained in primitive fashion by Chinese wooden chain pumps and water-wheels.

The wash may be left in heaps to dry in the sun, in which case the clay becomes hard and may be removed, leaving gravel only. The method of concentrating the gravel ore is by putting it into a trough some 30 ft. long, with an inclined bottom; water is allowed to run over it, and the mass is agitated by men wielding long hoes. The sand is washed away by the running water, and the concentrate mineral—which is two-thirds tin—is sent to the cupola furnace to be smelted. The furnace used is small—about 5 ft. high—and is made of clay strengthened with stakes and girt with iron rings. Charcoal and tin ore are put into the centre of the furnace, which has an aperture in the rear for the supply of a blast, produced by hand bellows, and for raking. The smelted metal runs from a hole in the bottom into a depression made in the ground and is ladled into moulds in the sand, which give it the form in which it reaches the market.

The alluvial deposits of New South Wales are found under sand dunes [see GEOLOGY] from 200 ft. to 300 ft. wide, and from 10 ft. to 20 ft. high, which have been formed parallel to the sea coast and run several miles inland.

These dunes are made up of a thick top layer of white beach sand, from 10 ft. to 15 ft. thick, under which are 2 ft. or 3 ft. of black sand, and finally about 1 ft. of gold and tin bearing sand on the top of red-brown sandstone rocks. The washing of this sand enables the recovery of the metallic tin, which is frequently associated with heavy proportions of gold and of good quantities of platinum, iridium, and other rare metals.

Tin Ore. *Cassiterite* (SnO_2), the oxide of tin, the form in which tin ore most frequently occurs, has a hardness between 6 and 7 according to Mohs' scale, a specific gravity of 6·8 to 7, and a chemical composition of 78·6 per cent. of tin and 21·4 per cent. of oxygen. These constituents vary in their proportions according as iron, manganese, copper, and other minerals enter into the composition of the vein. In appearance tin ore is dark red-brown or slate coloured.

Success in tin-mining depends more than in the case of most other base metals upon the skill which guides the mechanical preparation of the ore after mining. The ore is picked and sorted by hand, the non-stanniferous pieces being discarded and the true ore being put to one side. The latter is then passed through the stamp batteries. The stamp generally used in Cornwall weighs about 7 cwt., and makes about 60 drops of 10 in. per minute, crushing about 1 ton of ore every 24 hours. Greater efficiency could be attained by the use of more modern stamps, which would multiply output three or four times. The ore under the stamp is pulverised to a fineness that will pass through screens with about 144 holes to each square inch. The result is so much sand, and the problem now is to separate that part

of the sand which is really black tin from the worthless residue. To effect this separation, the greater weight of the black tin—which is rather more than double that of the sand—is made to assist. The crushed ore, carried by water, flows into tanks, known as *buddles*, which, in principle, consist of a series of tanks stepped one below the other, the heavy metallic particles depositing in the first and highest tank and the finest in the last and lowest. The bottom of many of these buddles takes the form of an inclined plane, with ridges right across its face, and on these ridges the heavy stanniferous sand settles. Again, the bottom may be made to move either by an agitating or by a rotary motion, and the results of these modifications are better than those attained by the original type.

The recovered black tin still contains many impurities. It is now passed through *tossing tubs*, or *chimming tubs*, which work on the same principle as the buddles, and the further purified tin sand is known as *whits*. This is now calcined in order to decompose the arsenical pyrites. Again the *buddles* and *tossing tubs* are called into service as often as may be required to remove the impurities, and the result is a cleaned and concentrated tin sand which is the marketable commodity known as *black tin*, containing about 66 per cent. of metallic tin.

Smelting Tin. The furnace used for smelting is of the reverberatory type [see page 270], with a bed about 18 ft. by 9 ft., and has a fireplace and a stack at opposite ends. The tapping hole is at the back, and is kept closed during the smelting. An ore charge weighs from 20 cwt. to 25 cwt.; and after being incorporated with about one-fifth of its weight of anthracite powder it is spread evenly over the furnace bottom. If necessary, fluor-spar or lime may be added as a flux. The door is closed and "luted" up—that is, plastered up with clay—and the heat raised for five or six hours, after which the door is opened, the heated mass is "rabbled," or stirred up, and some powdered anthracite is spread over the surface. After being heated again for about an hour, and a further stirring, the furnace is tapped. The slag left is chiefly ferrous silicate, but contains some tin, and it is usually heated afterwards to remove this.

Refining Tin. The processes we have described carry us to the point of refining. The refining proper is preceded by a preliminary liquation in a reverberatory furnace, which takes a charge of about 18 tons. The temperature is carefully watched, and as it rises to the point of melting, the purer tin is run off into a special pot or "kettle" heated by a separate fire. The impurities—iron, copper, sulphur, and other constituents—remain as *hard head*, a white, brittle mass which contains about 20 per cent. of metallic tin. The purer tin, which has run off, is retained in a molten state in its own kettle, and logs of green wood are plunged beneath its surface. Under the heat the wood gives off gas, which causes agitation of the molten metal, and the formation of a scum containing the impurities. The same result is sometimes attained by pouring the metal from a height of 17 ft. or 18 ft. into the kettle, this process also producing the scum and removing the impurities. The operations we have described give the commercial products known as *common tin*, or *refined tin* according to quality. For the latter, purer ores are used, and the refining is prolonged. *Block tin* is a lower quality than refined tin.

Alloys of Tin. Apart from its use as a coating on baser and cheaper metals, the chief industrial use of tin is in alloying with other metals. Although it is a soft metal, in combination with other soft metals it forms a hard alloy. Lead alloyed with tin has a higher malleability and ductility than pure tin, but a lower toughness. All soft solders have tin as a constituent [see Soldering]. In addition to soft solder, the tin-lead alloys include pewter and tinfoil [see also page 1457]. Pewter was formerly used extensively in the manufacture of domestic utensils, but the solubility of the lead made lead poisoning frequent if the proportion of lead were high. The maximum proportion of lead which should be used in tin-lead alloys for culinary utensils is from 10 per cent. to 15 per cent. The acids of fruit have no appreciable effect upon such an alloy, but if the lead be in excess of this it dissolves and enters into solution in the food.

Alloys of tin and lead are used in a molten state for tempering steel tools. The finer the tools the higher is the proportion of tin. Thus, for razors, penknives, and surgical instruments the proportion is about two parts of lead to one part of tin; while for small saws, the amount of tin is only one-twelfth that of the lead.

Tin-copper Alloys. The tin-copper alloys include bronze, gun-metal, and bell-metal. Ancient bronze was a dual alloy, containing only copper and tin, but the French bronzes of to-day are made of triple or quadruple alloys, usually the latter, consisting of copper, tin, lead, and zinc, and sometimes in addition with small proportions of arsenic, antimony, nickel, and sulphur. The colour of a tin-copper alloy varies from red to white, as the proportion of tin rises. From 90 per cent. copper to 70 per cent. copper, the colour ranges from red to orange yellow, pure yellow, light yellow, and white. Bronze increases in hardness as the proportion of copper rises to 35 per cent. of the alloy. From this proportion to an alloy with 73 per cent. of copper the brittleness is high, but as the copper exceeds the latter value, the tenacity increases. Gun-metal has 90 per cent. copper and 10 per cent. tin, this proportion being the mixture of maximum hardness.

Tin-antimony Alloys. Tin alloyed with antimony gives bearings metal and Britannia metal. Such alloys are harder and less malleable than pure tin, but are equally white. Increase in the proportion of antimony increases the brittleness. Tin-antimony alloys should be cast at as low a temperature as possible, so that the excess of antimony may not separate from the eutectic alloy. Ordinary Britannia metal usually contains not more than about 10 per cent. of antimony, the remainder being tin. Sometimes a small proportion of the tin is replaced by copper, and occasionally zinc or bismuth is also employed. A small proportion of bismuth increases the fusibility. The points of merit about Britannia metal are that alloys of tin and antimony yield good sharp castings, are tougher than tin, and take a better polish than tin-lead alloys. The manufacture of Britannia metal hollow-ware, such as teapots and coffee-pots, used to be a much larger Sheffield industry than it is. Nickel-silver has displaced it considerably. Most of the Britannia metal-ware now made in Sheffield is electro-plated. It can be distinguished from nickel-silver, because when struck sharply it sounds as a dull thud, whereas nickel-silver hollow-ware similarly struck gives a clear, sonorous ring.

Antifriction Metals. Bearings metal or antifriction metal is frequently an alloy of tin and antimony, containing about 20 per cent. of the latter. It is usually, however, not a dual alloy, but contains also copper, lead, or zinc [see also page 1458]. The formulas given for antifriction metals are very numerous, but that the science of eutectic

individually ...rfectly understood is proved by the satisfacto... done in proprietary antifriction metals, ment, ...position of which is not acknowledged.

poin... ...ys of tin and zinc are harder than tin, but ... so hard as zinc. Their use is limited. They are made into imitation silver leaf, and also cast into ornaments. The metals may be alloyed in all proportions.

Tin amalgam—that is, an alloy of tin and mercury—has a more restricted use than it had in the days when it was the agent adopted for silvering mirrors. Dentists use tin amalgam for filling teeth, one part of finely divided tin being triturated with four parts of mercury, and the excess of mercury being squeezed out in a chamois leather bag. The amalgam is pressed into the tooth and hardens in a few days.

Then we have alloys of tin, bismuth, and lead, used for type metal and printing blocks.

Tin-plates. Tin-plates are sheets of iron or steel, coated with tin. Sheets of Siemens steel are chiefly used for tin-plates, but charcoal-iron, which was, before the era of steel, the usual base, is still employed. Common qualities of tin-plate used to be made of puddled iron, and were known as *coke* plates, while *charcoal* plates were made from charcoal-iron. Bars of steel are made red hot, passed through chilled rolls, thereby being drawn out to about double length, folded in the middle, and again heated. Another rolling, another doubling, then another heating, rolling, and doubling takes place, until perhaps the final sheet contains as many as 32 plies. The sheets are trimmed to proper size, and the plies pulled apart, each ply then being a rough "black plate," so termed from its adhering coat of rough black oxide. This oxide must be removed before the plate can be tinned, and the operation, which is called *pickling*, is done with a warm solution of sulphuric acid in water for about fifteen or twenty minutes, followed by washing and rubbing with sand. *Annealing*, or maintaining at a high temperature for some time, then takes place. The annealing ovens are wrought-iron boxes of a size to hold the plates, and have removable upper parts, with joints that can be made tight against the ingress of air by being covered with sand. The annealing boxes are placed in a large furnace and kept at red heat for about ten hours, after which they are withdrawn, and the sheets are allowed to cool. After this, the sheets are rolled to give them smoothness, for a tin-plate can have a good surface only if the black sheet has had a smooth surface. The rolling may have made the sheets hard again, so a second annealing in cast-iron pots, and at a lower temperature, is given. Again the sheets are pickled, but in acid solution weaker than formerly, are rubbed with sand, and put into water to await the moment of entry into the tinning baths.

Plant for Tin-plates. The baths or pots used in the actual tinning process are usually five in number. The first is the grease-pot, which holds melted grease, such as tallow or palm oil, and the sheets are immersed in this until all water has evaporated from their surface, and they carry a uniform layer of grease. The second pot contains molten tin covered with a layer of grease, and the sheet is transferred from the grease and put into this, where it receives a coat of tin. The third pot is the washing-pot, also containing tin, and the sheet, with an imperfect coating taken on in the tin-pot, passes into the first compartment of the washing-pot, and acquires a uniform coating. The plate is removed and treated by a workman with a wire brush, who then puts the plate into the second compartment of the same pot, which is the final tin bath, and contains the best tin. The next pot is a grease-pot, in which the plate passes between carefully-adjusted rollers that remove excess of metal and give a better surface. The grease which adheres as it leaves this last pot is removed by rubbing with bran or sawdust, and a final surface is given by rubbing with a piece of the fleece of a sheep. The finished tin-plates are then examined for defects, and finally boxed for the market.

Varieties of Tin-plates. All the plates do not issue perfect. Defective plates are known as *wasters*, and if very bad, as *waste-waste*. In common tin-plates, *primes*—that is, sheets passed as perfect—usually amount to from 80 per cent. to 90 per cent. of the whole; but in charcoal plates the standard of quality allowed to pass inspection is much higher, and primes may be only 40 per cent. to 80 per cent. Wasters are sold as such, and there is always a market for them.

The commercial designations of tin-plate are very confusing, and the sheets are packed in boxes which are consistent neither in the number of sheets that they contain nor in weight. The table that follows gives the particulars of the various varieties and sizes. It is, indeed, time that some simpler method of packing and indicating tin-plates should be adopted. Cumbrous and awkward systems of reckoning also prevail in the manufacturing processes, but into these we cannot enter.

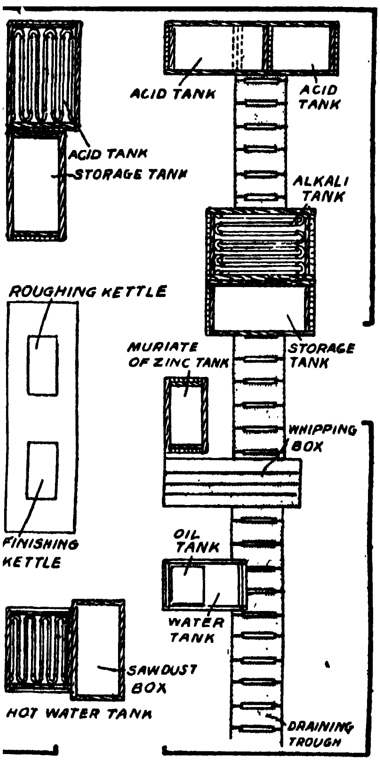
THE TIN-PLATES OF COMMERCE

Description	Mark	Dimensions of Sheets	Number of Sheets in a Box	Weight of Each Box
		Inches	Sheets	Lbs.
Common No. 1... ..	IO	14 × 10	225	108
Cross No. 1	IX	14 × 10	225	136
Two crosses No. 1 ..	IXX	14 × 10	225	157
Three crosses No. 1 ...	IXXX	14 × 10	225	178
Four crosses No. 1 ...	IXXXX	14 × 10	225	199
Common No. 1	IC	14 × 20	112	108
Cross No. 1	IX	14 × 20	112	136
Two crosses No. 1 ...	IXX	14 × 20	112	157
Three crosses No. 1 ...	IXXX	14 × 20	112	178
Four crosses No. 1 ...	IXXXX	14 × 20	112	199
Common No. 1.. ..	IC	28 × 20	56	108
Cross No. 1	IX	28 × 20	56	136
Two crosses No. 1 ..	IXX	28 × 20	56	157
Three crosses No. 1 ...	IXXX	28 × 20	56	178
Four crosses No. 1 ...	IXXXX	28 × 20	56	199
Common No. 1.. ...	IC	12 × 12	225	108
Cross No. 1	IX	12 × 12	225	136
Two crosses No. 1 ...	IXX	12 × 12	225	157
Three crosses No. 1 ...	IXXX	12 × 12	225	178
Four crosses No. 1 ...	IXXXX	12 × 12	225	199
Common doubles ...	DC	17 × 12½	100	94
Cross doubles	DX	17 × 12½	100	122
Two-cross doubles ...	DXX	17 × 12½	100	143
Three-cross doubles ...	DXXX	17 × 12½	100	164
Four-cross doubles ...	DXXXX	17 × 12½	100	185
Common doubles ...	DC	17 × 25	50	94
Cross doubles	DX	17 × 25	50	122
Two-cross doubles ...	DXX	17 × 25	50	143
Three-cross doubles ...	DXXX	17 × 25	50	164
Four-cross doubles ...	DXXXX	17 × 25	50	185
Common doubles ...	DC	34 × 25	25	94
Cross doubles	DX	34 × 25	25	122
Two-cross doubles ...	DXX	34 × 25	25	143
Three-cross doubles ...	DXXX	34 × 25	25	164
Four cross doubles ...	DXXXX	34 × 25	25	185
Small common doubles	SDC	15 × 11	200	167
Small cross doubles ...	SDX	15 × 11	200	188
Small two-cross doubles	SDXX	15 × 11	200	209
Small three-cross doubles	SDXXX	15 × 11	200	230
Small four-cross doubles	SDXXXX	15 × 11	200	251
Small common doubles	SDC	15 × 22	100	167
Small cross doubles ..	SDX	15 × 22	100	188
Small two-cross doubles	SDXX	15 × 22	100	209
Small three-cross doubles	SDXXX	15 × 22	100	230
Small four-cross doubles	SDXXXX	15 × 22	100	251

Terne Plates. Terne-plates are made in the same way as tin-plates, and differ from them only in that the coating given to the black plate is an alloy

of tin and lead. The proportions of the mixture vary with different manufacturers, but a frequent and a satisfactory mixture contains 75 per cent. of lead and 25 per cent. of tin. Such plates are used extensively for roofing purposes, particularly in the United States, in Russia, and in mid-eastern Europe.

Uses of Tin-plates. Steam power and machinery have revolutionised the working of manufactured tin-plates. "Pieced" work, so-called—that is, articles made by the tinsmith, who cuts out and puts together pieces of the plate to make tin hollow-ware—has been superseded by the product of stamping machinery. The largest consumers of tin-plates in the world are the petroleum oil com-



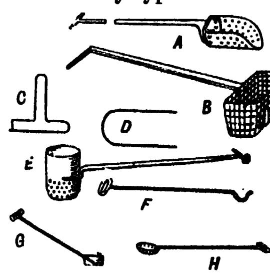
1. TINNING PLANT

panies of America and Southern Russia, who manufacture square tins in which to export much of their refined oils. The packing industries in Chicago and elsewhere are also large consumers, as well as the fruit and fish canners.

But besides the tinning of black plates, which is a localised industry, and in this country confined to South Wales, the process of tinning finds a wide scope in coating all classes of manufactured iron, steel, and metal articles, from pins to saucepans, from harness buckles to meat tins. For such work, a detailed description of the plant and processes may serve some good purpose in this article, because, while there is small likelihood that any student of these pages will desire to set up tin-plate works, it is more than probable that many may desire to install tinning plants as finishing departments of metal-working businesses.

Tinning. The operation of tinning resembles in many respects that of galvanising by the hot process. Articles are galvanised to protect them from rust. The more expensive proc has the same object, but the zinc co former process is not suitable for articles fo purposes, and in the sphere of cooking u and for food containers tinning finds its grea field. Tinning also remains brighter than galvanising, although those not thoroughly familiar with the distinctive appearance of galvanising and tinning may often mistake a badly tinned article for a well galvanised article. Tinning was in vogue for coating articles of malleable iron, and of wrought iron and steel long before it was used for common cast iron. The process upon the latter material is a little more difficult, and it will demand special treatment.

Tinning Plant. A description of a tinning plant will be more lucid if we take a typical case, but it cannot be claimed for any typical case that its details are suitable for all cases. The requirements of the work must modify the details in installing a plant for a particular purpose. A good general arrangement for a tinning shop is shown in 1, and the purpose of the various fixtures will be explained as we describe the process. The small hand tools necessary are modified by the nature of the work done, but the tools shown in 2, and also used for galvanising, serve most purposes in the tinning shop.



2. HAND TOOLS FOR GALVANISING AND TINNING
A. Dross scoop *B.* Wire dipping-basket *C* to *F.* Wires for small work *E.* Sheet-iron basket *G* and *H.* Skimming tools

Preparing the Work. The smoothness of the coating of tin depends quite as much upon the metal surface as upon the even deposition of the tin envelope. Common articles are cleaned from rust, sand, and adhering dirt, by immersion in acid—sulphuric acid, muriatic—otherwise called hydrochloric acid—or hydrofluoric acid. Where a better coating is desired, the articles are further prepared by rolling them in special barrels with gravel and water. These barrels, made of a convenient form and size for the work, are caused to rotate upon a horizontal axis, and the agitation and friction makes the articles within smooth to a degree proportionate to the time during which they are subjected to this treatment. When extra fine results are desired, the articles may receive a second rolling in coarse dry sand, and even a third rolling in scraps of leather, but common work seldom warrants the expense of this extended treatment.

Wrought iron and steel can have rust and scale removed in a pickle made of sulphuric acid diluted with water to thirty times its volume, or with muriatic acid diluted to fifteen times its volume. Hydrofluoric acid is sometimes used, and is much quicker in its action, and is less likely to injure the castings. The strength is from 1 in 20 of water to 1 in 30. The pickle should be kept warm at, say, 150° F. Stirring is necessary during the process if the articles are of such a form that the surfaces of different articles are liable to rust in the bath in contact with each other, thereby preventing the acid from getting to its work. Sheets of iron or steel are placed in wooden racks arranged to keep them apart. Every article should be examined

individually as it comes from the bath, and if not satisfactory, should be subjected to further treatment, or should have any scales removed with a pointed instrument, such as an old file. Small articles are then "rolled" in barrels, as already described. This process does not increase the adhesion of the tin coating; it merely gives a smoother surface. Over-pickling, which is apt to follow the use of sulphuric or muriatic acid, makes the work pitted, and care must be taken to avoid it.

If the articles be sandy, every particle of sand must be removed, or bad work will result. This may be done in the manner described later for preparing work to be galvanised. Washing with the aid of wire brush rubbing may be necessary to remove the sand perfectly.

Malleable castings should always be rolled with dry, sharp sand or shot, to secure a good surface. If the articles have paint or grease on their surfaces they should be immersed in a hot, strong solution of caustic soda, and then washed in clean water, finally going to the pickling tank to have the rust and scale removed.

After being cleaned by one or more of these processes, the articles are put into a tank with clean water—not into running water, which would cause oxidation—until they are wanted for the tinning kettle.

Dipping the Articles. Small work is usually strung on wires for immersion. Make the wires long enough so that there may be plenty of room to put the articles well into the tin. Take a wire laden with articles, immerse the latter for a few minutes in a tank containing a solution of muriatic acid (1 to 5) to remove any remaining traces of rust, then into muriate of zinc solution (zinc chloride) made by dissolving zinc in muriatic acid to saturation point, and finally put into the kettle of molten tin.

Common work is often done in a plant with only one tinning kettle. The diagram [1] provides for two kettles, which are almost essential. With one kettle the slag or dross which accumulates on the surface is apt to adhere to the finished articles.

Several wires filled with work are put into the kettle and allowed to remain there until the articles are as hot as the tin, which should be about 500° F. When this point is reached the work is withdrawn, care being necessary in the manner of withdrawal. With a ladle held in the right hand, clear the surface of the molten tin free from slag, so that no slag or flux may be carried away by the articles as they are withdrawn. Then withdraw a laden wire and plunge it immediately into the second kettle, which should have a temperature of about 400° F., or 450° F. for very small articles. Care should be taken that none of the surface slag or flux is taken over by the work into the second kettle. The second kettle should have a layer of tallow on the top, to the depth of ½ in. or 1 in. When the temperature of the articles in the kettle has fallen to that of the second kettle they are withdrawn, swung around sharply so as to throw off any surplus metal, and then thrown into a tank of kerosine oil. This tank has a water jacket, preferably with circulating water, to prevent the oil overheating. In this tank the tin coating sets, and when the work is withdrawn from it, which may be at any convenient time after the tin has set, it is thrown into clean sawdust, which takes up the oil. The operation of tinning is now complete, and if the proper method has been followed, and care exercised, the articles have a smooth coating, uniform in depth and colour.

Preparing Gray Cast Iron for Tinning. To get a good coating on common gray cast iron, several precautions in addition to those used for ordinary wrought iron and steel, and for malleable cast iron, are necessary. If grease or paint be present, or if there be traces of resin from resin cores used in the moulding, the articles should be washed in a strong hot aqueous solution of caustic soda, as already described for removing grease in tinning wrought iron. Castings have always some adhering sand; this should be removed with hydrofluoric acid and water, as already described. Sulphuric acid or muriatic is often used, but hydrofluoric acid is preferable, as it dissolves the sand—not dislodging it only—and does not attack the iron as the other acids do.

Of the several other processes employed to make common gray castings suitable for a deposit of tin, one successful process may be described. A special tumbling barrel, containing a mixture of muriatic acid, sal ammoniac, and water, is used. The barrel should be much stronger than an ordinary tumbling barrel. A body ⅜ in. thick, with cast-iron heads 1½ in. thick, are good sizes. The manhole cover will serve if 1 in. thick, and well supported with ribs. This strength is necessary to withstand the action of the gases generated by the chemicals used, and valves should be provided to permit the escape of these gases. Place the cleaned castings in this barrel, and let one-fourth of the inside capacity be occupied by "stars"—small castings of the shape indicated by the name and used in ordinary tumbling—and shot; then add water until the barrel is three-quarters full, and finally put in 15 lb. of muriatic acid, and 2 lb. of sal ammoniac. Close the manhole and set the barrel in revolution. Soft iron requires about 2½ hours of such rolling, and hard castings may require double this time.

Then the work is withdrawn from this barrel and placed in the storing tank (containing clean water) until it is to be put into the kettle to receive its bath. When that time comes the castings, either strung on a wire or in a wire basket, are immersed in a boiling solution of caustic soda or potash for about two minutes; this is followed by rinsing in water, then by a bath in a weak solution of muriatic acid (1 in 40), then by immersion in muriate of zinc—prepared as already described—to every gallon of which 5 lb. of sal ammoniac has been added, and finally, into the first tinning kettle at 500° F. This kettle should have a special flux on the surface prepared by boiling muriate of zinc on top of the tin and adding thereto some sal ammoniac. The consistency of this flux is an essential to good work. If it tends to become thick or hard, add more of both ingredients, and remove any hard part with a skimmer. Then the second kettle is called into operation in due course, and as already described, and the subsequent oil bath and sawdust.

Recovering Waste Tin. Many thousands of pounds sterling are wasted annually in the tin which adheres to tin-plate scrap, and many solutions of the problem of how to recover this tin have been sought. Nearly all successful processes are secret.

Any process of recovery which has depended upon an acid solvent has proved far too costly. The solvent invariably attacked the iron below the tin, became soon exhausted, and had to be frequently renewed. Success is possible only by an electrolytic process, similar to that employed in the manufacture of electrolytic copper. One such process may be described. The electrolytic bath is said to be a solution of caustic soda, or of sodium nitrate, and the scrap tin-plate, of course, forms the anode.

The tin-plate scrap, freed from grease if necessary, and compressed so as to take up as little room as possible, is suspended in wire baskets in a wooden tank. Between the various baskets copper cathode plates are suspended. Both the baskets and the cathode plates are suspended so as to be clear of the bottom of the tank, where sludge accumulates. The solution is made of 30 lb. of caustic soda in 100 quarts of water, and in use is maintained at about 150° F. by an exhaust steam coil. The solution is made to cover both baskets and the cathode plates. The electric current causes the tin to deposit on the cathode plates as a spongy mass, which is easily detachable by hand. This mass must not be recovered in the presence of air, or it would oxidise away. It is covered with powdered charcoal and coke breeze, and is melted in a closely-covered crucible.

ZINC

Zinc was one of the last of the common metals to come into extended industrial use. There is evidence that it was known to the ancients, because zinc bracelets have been found in the ruins of Eastern cities which were destroyed several centuries before the opening of our era, but the knowledge was evidently lost, because during the long Middle Ages zinc was unknown to Europe as a metal. True, brass used to be manufactured by heating copper in a mixture of calamine (the ore of zinc) and charcoal, but the metal zinc was not known to be procurable from this ore. During the third decade in the eighteenth century Henckel discovered that zinc could be obtained from calamine. But it was about a century later before what may be termed the zinc industry was established. Thus, zinc may be said to be about one hundred years old as a commercial product, and the process of galvanising, or coating iron sheets with molten zinc, to impart powers of resistance to corrosion, was first applied only seventy years ago.

The world's chief sources of zinc ore are Germany, Italy, Spain, France, Sweden, Austria, Algeria, Great Britain, New South Wales, Greece, and Belgium, this being the order of importance. The chief producers of zinc are Germany, Belgium, France, and Great Britain, in the order named. Thus, the smelting and refining of zinc ores does not belong essentially to the districts where the ores are found. Zinc ores carry high percentages of zinc, so that transport in their unreduced state is relatively inexpensive.

Zinc Ores. There are two main zinc ores—*calamine*, or carbonate of zinc ($ZnCO_3$), and *zinc blende*, or sulphide of zinc (ZnS), which the miners term "black jack," on account of its deep black colour. Minor sources are the oxide of zinc, which usually occurs in combination with oxide of manganese and zinc silicate.

Characteristics of Zinc. Zinc is a bright bluish white metal, with the atomic weight 65·4, a specific gravity of about 7·125, which rises if it be cooled rapidly, and a melting point of 415° C. In Mohs' scale of hardness its place is 2·5. Its boiling point is 920° C., but it burns in the atmosphere at a temperature of 500° C. The texture of zinc is laminar, sometimes granular. Its fracture is granular or crystalline according to the temperature to which it has been raised in casting, and is easily recognisable. When heated over 100° C. the metal becomes ductile and may be rolled into rods or sheets, or drawn into wire. After cooling subsequent to this treatment, it remains ductile. The tensile strength of zinc is between 7,000 lb. and 8,000 lb. per square inch of section; its thermal conductivity is 28·1 (silver = 100), and its electrical conductivity is 16·92 (mercury at 0° C. = 1).

The ores are formed in two distinct forms—in mineral veins and in irregular deposits. Of the former class zinc blende is the most abundant, and within the last two decades it has taken place above calamine, which was the first form of zinc ore to be treated.

Preparing Zinc Ores. Since the inception of the zinc smelting industry, the plants and processes employed have undergone modification, and we shall consider only those practised to-day in modern works. There are two main processes, termed respectively the Belgian and the Silesian. They differ in the retorts and furnaces used, and in the methods of handling the ore. Zinc ores, having been raised to the surface, are concentrated so that the cost of furnace treatment may be reduced. Concentrating merely means rejecting the valueless or objectionable portions of the ore mass, leaving the selected rich pieces to be treated. Three processes of concentrating are in practice, and specific ores may be subjected to one, to two, or to all three of these processes, which are hand separation, gravity separation, and magnetic separation. The processes employed in individual cases depend upon the class of ore under treatment.

The ore as brought from the shaft is usually broken either mechanically by jaw crushers or by hand. The latter practice is the better, although the more costly. It is usually practised when low wages rule in the district. Hence it is common in Central Europe, but infrequent in America. Mechanical breaking causes too heavy a loss by making "fines," or dross, and it is valuable zinc-carrying rock that is most easily made into fines. Hand-breaking with hammers is thus the better practice.

Having been broken, the ore is screened to remove the fines. The remainder is then sorted by hand. The best method is by a circular revolving table, or by a long belt conveyer. In either case the work moves in front of the operator at suitable speed, and he or she (for in Continental Europe the sorters are often women) removes the pieces according to instructions, putting the waste aside and retaining the blende or calamite as the case may be.

The process of gravity separation requires, first, that the ore should be crushed to such a fineness that the minerals are well separated. The crushed ore is carefully screened, which grades it into various sizes, and each size is washed and treated by itself in tanks or buddles, such as are used in other metallurgical processes, and which are described in Tin Recovery.

The magnetic separation in zinc ore concentration is practised in New South Wales and in America. It is somewhat costly, involving the use of expensive plants, but it has been found to be remunerative. Zinc and zinc compounds are non-magnetic, or, at most, only feebly magnetic. But if the associated minerals in the zinc ores are magnetic, they can easily be separated by magnetism. For instance, in Bohemia iron in the form of siderite is separated from zinc by heating the mass, then grinding it and screening it, and finally treating it in magnetic separators. In Pennsylvania also the zinc ores which carry franklinite, willemite, calcite, zinkite, and tephroite, are separated by a direct magnetic process without previous roasting.

Calcining Zinc Ores. When the ore has been concentrated in the manner described, it must be calcined to remove the carbon dioxide and water, and also to make it more porous. Roasting decomposes carbonate of zinc into zinc oxide and carbon

dioxide, and nearly all of the latter is driven off. The roasted mass weighs only about 65 per cent. of its original weight.

The process of roasting may be carried out in the open, the ore being piled in heaps, or it may be done in reverberatory or shaft furnaces. The first method is the most costly and wasteful, and is not suitable for calamite, although it was formerly employed for "blende" ores. Some sulphide ores (such as nickel ores) are roasted in the open, as their sulphur contents supply a great proportion of the heat necessary for their calcination. Thus for zinc a furnace of some sort is almost invariably employed. A common shaft furnace of the limekiln type may serve, but it has the objection that the calcined ores are mixed with the fuel ashes. Such furnaces run to 20 ft. high, and treat up to 30 tons each 24 hours, the fuel consumption being from 3 per cent. to 6 per cent. of the ore before treatment. The shaft furnaces are sometimes grate-fired; these give a cleaner result, but are more expensive in fuel charges, these running from 6 per cent. to 9 per cent. of the raw ore. Their capacity also is only half that of the ordinary shaft furnaces.

Several varieties of the reverberatory furnace are employed, and these furnaces are the only suitable means of treating "fines." They are more expensive than shaft furnaces in both labour and fuel. Sometimes they are heated by the waste gases from reduction furnaces. In Kansas and Indiana natural gas supplies the fuel.

Calcining Zinc Blende. *Blende*, the sulphide ore of zinc, must be calcined to reduce the sulphide to an oxide, and the contained carbonates, if any, must also be converted into oxides. In practice, it is found impossible to remove the sulphur entirely, and up to about 2 per cent. may remain. The ore must be finely crushed, and may not be coarser than can pass a mesh of $\frac{1}{12}$ in. Calcination of zinc blende reduces its weight by 12 per cent. to 20 per cent. The operation is performed in shaft, reverberatory, or muffle furnaces. Preliminary roasting is frequently conducted in shaft furnaces, and the sulphur, which may have been up to 30 per cent. to 35 per cent. of the raw ore, is reduced to 7 per cent. or 8 per cent. The sulphur dioxide given off may be used for the manufacture of sulphuric acid.

The final roasting when shaft furnaces are used for the preliminary roasting—or the only roasting if the shaft furnace has not been used—takes place in either a reverberatory or a muffle furnace. The former is adopted when the gases given off are not to be used, and the latter when they are to be used for sulphuric acid manufacture. Muffle furnaces yield gases rich in sulphur dioxide, and calcine the ore thoroughly. The gases of reverberatory furnaces, on the other hand, give gases very low in sulphur dioxide, which cannot be profitably utilised. Before the gas can be allowed to pass into the atmosphere, however, it must be diluted or otherwise treated so as to render it innocuous.

Zinc Distillation. The next process in the treatment of zinc ore after it has been concentrated and converted into oxide is the recovery of the metal by distillation. Zinc oxide when heated to a high temperature is reducible by carbon or carbon monoxide. Practice employs a heat of 1300° C., although the precise reduction heat is below this. The metal is reduced in retorts or muffles to the form of vapour, which is liquefied by cooling to about 500° C., and is collected in clay vessels called *receivers* or *adapters*.

The Belgian retorts have a round section, the Westphalian are of oval shape with a flat base, and the Silesian are ⌂-shaped. They are usually made of fireclay and burnt clay, and it is essential that they should be of as refractory a nature as possible. The receivers or adapters in which the zinc vapour condenses are short tubes of clay which are luted to the end of the retorts. The furnaces in which the retorts are heated are shaft furnaces, and are fired externally. The retorts are ranged in tiers, and slope forward in the furnaces. The zinc oxide is charged into the retorts with from 40 per cent. to 60 per cent. of its weight of coal or coke. Sometimes the charge is pressed into blocks with tar. The actual process of distillation requires care. The furnace is fired for some days before the retorts are charged, and at first the charges which are introduced into the retorts after removing the adapters are light, but are gradually increased. A retort charge is usually about 63 lb. of ore, and is reduced in twelve to twenty-four hours. The condensed zinc is raked into ladles from the adapters into iron moulds, and forms ingots weighing from 40 lb. to 44 lb. After a charge has been reduced the residue is raked from the retort, which is again charged with a fresh supply of material, and the process is repeated as before.

Refining Zinc. The zinc drawn from the adapters may be sufficiently pure for commercial purposes if the ores have been carefully selected, but it may, on the other hand, contain fair proportions of iron and lead, which can be removed by a simple process of refining. The crude zinc is melted gradually again, and kept in that state for some time. The iron rises to the surface, and may be removed as scum. The lead sinks to the bottom and the zinc may be drawn off, leaving the lead; or the underlayer of lead may be removed by an endless screw working in a cast-iron pipe. The higher the purity of the zinc the greater its value, and while pure zinc is almost impossible to obtain, care in selecting the ores and in the subsequent treatment will give something approaching chemical purity.

Zinc Alloys. The most important use of zinc is in the galvanising trade, and the processes of galvanising are discussed later. The next most important use is as a constituent of alloys. In alloying, many metals—including tin, nickel, aluminium, manganese, iron, and copper—exercise a stronger colour influence than zinc, while zinc has a stronger colour influence than lead, platinum, silver, and gold. This means that the metals which we describe as having a stronger colour influence impart their colours to those lower in the scale to an extent much higher than their proportion of the alloy. The most important binary alloys of zinc are with copper and with aluminium. Zinc-copper alloys form brass and yellow metal, and these constitute a science in themselves [see next article]. The two metals unite in all proportions, but for industrial use the proportion of copper is seldom less than 50 per cent. When zinc is in excess the alloy loses strength, and the higher the excess of zinc the weaker and harder is the alloy. Increase in the copper proportion of a zinc-copper alloy gives a deeper colour, at the same time increasing the malleability and softness. Alloys having up to 35 per cent. of zinc can be rolled and drawn only if cold; if the zinc proportion be from 35 per cent. to 40 per cent., the alloy can be worked either cold or hot. Brittleness, and therefore difficulty of working, increases as the zinc increases. The most ductile alloy contains from 15 per cent. to 20 per cent. of zinc, and sheet brass for fine work has this proportion. Brass for

cartridges has 28 per cent. of zinc. Cast brass usually contains more zinc, as it is the cheaper ingredient, from 30 per cent. to 40 per cent. being common.

Alloys of zinc and aluminium are important industrially, especially since the reign of the motor-car began. Castings containing from 25 per cent. to 33 per cent. of zinc are clean and sharp, besides being very strong and capable of being machined easily.

With lead, zinc has very little alloying power, as the two metals unite to a very small extent. Each of them can dissolve not more than 1·6 per cent. of its fellow. Bismuth and zinc are also unsuitable for alloying. It has been found that zinc can dissolve only 2·4 per cent. of bismuth, and bismuth can dissolve not more than 14·3 per cent. of zinc. Zinc amalgam—that is, an alloy of zinc and mercury—is used in the zinc anodes of galvanic batteries. In its preparation, a zinc plate is heated to about 500° F., and after being coated with a brush with a solution of chloride of zinc and ammonia, it is dipped into mercury. Anodes prepared thus give currents more constant and intense than do ordinary zinc plates.

Sheet Zinc. Zinc has been used as a roofing material for about a century. Nowadays, galvanised steel sheets have a much wider application than zinc sheets for roofing. But the life of a galvanised iron roof is seldom longer than fifteen years, even with periodical painting, while the life of a zinc roof is indefinite. Some zinc roofs are in good condition after forty years of service. The sheets of zinc used for roofing should not be soldered when they are to be subject to wide degrees of temperature, as the contraction and expansion of zinc is higher than those of other roofing metals. Nails used with zinc roofing should be of zinc, or, at least, should be galvanised. A zinc roof has the advantage of lightness, being only about one-fifth as heavy as a lead roof—zinc sheets being thinner than lead sheets—and one-tenth as heavy as tiles.

Other uses of zinc sheets include their suspension as plates in boilers to prevent corrosion of the boiler shells. The galvanic current which they induce causes the lime and organic matter to act upon the zinc instead of on the boiler, thereby protecting the latter. Thin zinc sheets, sometimes purchased as flat discs and sometimes turned off the zinc bar in spirals, are used in gold extraction by the cyanide process. Perforated sheet zinc—the perforations being round or ornamental in form—is used extensively for ventilators, and for domestic meat safes. As lining for packing-cases and coffins, as a material for hollow-ware, such as watering-cans, buckets, etc., sheet zinc has a limited but useful consumption. The printing trades use zinc extensively for process blocks.

Other Uses of Zinc. Zinc castings—except so far as zinc enters into brass as an alloy—have not an important industrial use, but many cheap ornaments are made of cast zinc, electroplated or otherwise finished.

Zinc oxide, or *zinc white*, as it is termed commercially, is prepared by burning zinc and leading the fumes into condensing chambers. It is used as a pigment, and also in medicine. *Zinc chloride* is used as a caustic in medicine, and also for weighting cotton goods, and in mercerising cotton. *Zinc sulphate* is used in dyeing, in calico-printing, and in medicine.

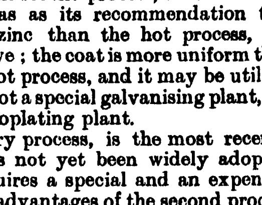
Among the cheaper metals, zinc excels in the property of resisting atmospheric action. For this reason iron and steel, and sometimes other metals, are given a thin coating of zinc, which presents a closed surface to the agents of corrosion and oxidation, and prevents these latter from penetrating to the surface beneath. The process of zinc coating is termed *galvanising*.

Processes of Galvanising. There are three different processes of galvanising—the hot process, the electrolytic process, and the dry or oxide process. The first named is the original process, and is practised by nearly every firm who do galvanising work. It has many advantages, although it has a few disadvantages; but the former have, up to the present, been held to warrant faithfulness to it. It is suitable for all classes of work—sheet, cast, and wrought iron and steel. The plant must be large enough to handle the articles to be galvanised, of course, but there is no class of work that cannot be undertaken by it. No other method is suitable for what is termed *galvanised hollow-ware*—that is, articles such as buckets, bins, water-pots, and other containers of sheet iron or steel that have to be galvanised. Such articles are made with seams which are not always watertight, but the molten zinc during the process of galvanising lodges in these seams, doing duty as a solder, and rendering the vessel free from leaks. The hot process also is capable of giving a *watered* or *spangled* effect which no competing process hitherto tried is able to produce. This surface is for some purposes better than the uniform gray surface attained by other processes. It may be noticed often, but not always, on galvanised corrugated iron and on galvanised buckets. The second process, that of electrolytic deposition, has as its recommendation that it uses much less zinc than the hot process, and may be less expensive; the coat is more uniform than that given by the hot process, and it may be utilised by firms who have not a special galvanising plant, but who have an electroplating plant.

The third, or dry process, is the most recently introduced and has not yet been widely adopted. Except that it requires a special and an expensive plant, it has all the advantages of the second process, to which we have made reference. Its special value lies in its cheapness. It is eminently suitable for small castings, stampings, or forgings. It is the patented process of Mr. Sherard Cowper-Coles.

We may now proceed to consider in some detail the several processes.

Plant for Hot Galvanising. In preference to describing the enormous plants that exist in the large galvanising works, we shall give attention to the needs of a man who wishes to install a plant for small requirements. Work for a large galvanising plant must come forward with regularity and in large quantity. The bath of molten zinc, usually containing several tons of metal, must be kept hot constantly whether work is going through it or not, because if the bath, or *kettle*, be allowed to cool—that is, to solidify—it cannot be melted again without breaking up the kettle—an enormous expense which every galvanising works manager is careful to avoid. But nothing so



3. GALVANISING PLANT

disastrous follows the solidifying of a kettle containing two or three hundredweights of zinc, although it is better that even these should be kept in constant work.

A galvanising plant should be situated in a separate building, as the fumes from the acid used are destructive to tools and machinery. The building should be well ventilated, the water supply abundant, and the drainage perfect. In 3 we show a good arrangement for a galvanising plant, and the various parts of the plant should be as follow.

Galvanising Kettle and Tanks. The kettle is a long trough built in brickwork, having flues some way up the sides. It should be not less than 36 in. long, 20 in. deep, and 18 in. wide. This size would be of no use for large work, such as corrugated sheets, which, however, would not be handled by a small plant. The kettle should be made of best fire-box steel, not less than ½ in. thick. A good sectional view of an efficient kettle of small size is shown in 4. The fire underneath must be of a size to keep the zinc in a molten condition.

GALVANISING KETTLE

The tanks for acid and cleaning liquid are merely rectangular boxes of a suitable size. If it be desired to economise, an oil barrel, sawn in halves, will make two suitable tanks. It is sometimes considered well to have the acid tanks lined with lead, but this is by no means necessary, and the expense may well be saved.

Sundry Tools. The hand tools used by galvanisers consists of tongs of a shape suitable for the work to be undertaken, of baskets of woven wire or perforated iron, and sundry wire tools, bent to different shapes. In 2 are shown some tools generally used, and the description attached explains their purposes sufficiently.

Firing the Kettle. Some precaution is necessary in firing a kettle for the first time. The fire should not be allowed to raise too great a heat before the zinc, or *spelter*, as ingot zinc is called, has begun to melt, or the shell of the kettle will suffer. The blocks of spelter should be made to lie right on the sides of the kettle, so that as the blocks next the kettle melt the other blocks will be forced into the same positions. The bath may be kept at a uniform temperature by the use of a pyrometer, and some device is usually adopted to prevent the stem of the pyrometer from contact with the molten zinc, although making the same record as if it were in direct contact. A device sometimes adopted is to have the pyrometer stem in a steel tube, closed at its lower end and filled with lead, in the middle of which the stem rests.

Removing Scale. Most work to be galvanised must have scale and rust removed before it is sufficiently clean to result in good work. This process is known as *pickling*. It is accomplished by immersing the work in a solution of 1 part of muriatic acid (otherwise known as hydrochloric acid or spirit of salt) in 20 parts of water. It may be necessary to assist the removal of the scale with a tool such as a wire brush or file. A weaker acid solution should be used for work with an unequal scale, otherwise *over-pickling* may take place, and this seriously prevents the adhesion of a good deposit of zinc. Sandy castings are cleaned by pouring over them a solution containing one part of sulphuric acid to six parts of water. They should be placed on a table or tray, and have the solution poured over them about every hour until the sand can be entirely removed by washing with water.

The Acid Bath. The work is immersed in muriatic acid before going into the zinc kettle. This acid serves as a flux, and also cleans the surfaces finally. If the work has some adhering rust, it should be kept in this bath long enough to remove the rust. The acid used is sometimes full strength, but a better bath is equal parts by volume of muriatic acid and water, with 1 lb. of sal ammoniac added to each gallon of liquid.

From the acid bath the work is taken to be dried, and many methods of drying are adopted. In a small plant, the drying table may be heated from the fire that supplies the kettle, but in big plants separate fires are used for drying the work. The muriatic acid should be apparent on the dried work as a white adhering powder. After drying, the articles should be put into the zinc kettle before they become cold.

The Molten Bath. The molten zinc should be at a temperature suitable for the work being put through, and a pyrometer is the only means of getting exact results. Different classes of work require different degrees of fluidity, or, in other words, different degrees of heat. For large gray iron castings, the metal should be about 775° F., and for thin work, where the spangled effect is desired, this heat is right. For wrought-iron pipe, heavy malleable castings, and small castings used without a flux a good temperature is about 840° F. For nails and other small work, hung on wires or immersed in baskets, about 880° F. is the best heat. The surface of the molten bath at the place where the article is about to be dipped should have thrown on it a few handfuls of sal ammoniac, which, whenever it is melted, should be followed by a few drops of glycerine, to restrain it from spreading over the entire surface.

Dipping. The manner of dipping the articles depends upon their nature. Washers, for instance, are strung on wires, nails and small articles are put into wire baskets, and large articles are simply held with tongs. The immersion should be made as quickly as possible, without causing sputtering, and the article should be held beneath the surface of the molten zinc until it is as hot as the zinc itself. This time cannot be judged by rule, and the only teacher is practice. When the article, say, a thin casting, has been immersed some time, it should be rinsed around a little. Before removing it, clear a space on the surface where it will emerge, and dust that part of the surface with a little sal ammoniac in powder. With one pair of tongs raise the article out of the metal, and with another pair, not dipped into the actual bath, complete the withdrawal. Some goods, such as galvanised hollow-ware, require immersion for only a few seconds, and the surface need not be sprinkled with sal ammoniac before withdrawal. Indeed, slight differences in the minute details of the practice give better work with different articles, and all these details can be learned only by practice. Wire and netting are run through the bath by a reel arrangement, and some galvanisers of corrugated sheets adopt a revolving wheel device to throw up the sheets after coating. The particular practice must be adapted to the particular work to secure the greatest possible economy.

Cooling. The articles are sometimes allowed to cool in the air, are sometimes immersed in cold water at once, and, sometimes, again, the cooling water is heated, so that the cooling may not be too sudden. If the article has taken on any of the sal

ammoniac floating on the surface, a wet brush may be used to remove it.

Dross. Every galvanising kettle accumulates dross. This is caused by impurities and dirt which accompany articles into the bath and remain behind, and sometimes by having the metal at too high a temperature. The dross should be removed periodically, as it retards the work and causes fuel expense if it remain. It is removed with a dross scoop [2], and must be done smartly, and deposited quickly, before it has time to harden on the scoop. The good zinc is sometimes recovered from the dross by heating to a high temperature—over 1,000° F.—with lead. The mass, on settling, has the lead at bottom, with the dross next to it, and the good zinc at the top, whence it may be removed and utilised.

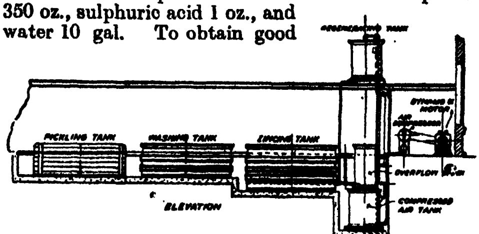
Electro-galvanising. The second process of galvanising, to which we shall devote some attention, is the electro-deposition of zinc. Where the highest degree of adhesion of the zinc to a piece of iron or steel is sought, it is attained best by the method of electro-deposition. Thus, for boiler tubes, and for the hulls of torpedo boats, electro-zincing or electro-galvanising is superior to the "kettle" method. Exhaustive tests have shown that electro-galvanising does not diminish the tensile strength of the material to which it is applied, as does hot galvanising. Also, the coating imparted can be gauged much better than with the more common process.

The Cowper-Coles Process. There are several processes employed for the electro-deposition of zinc, but we shall confine our remarks to the Cowper-Coles process, on account of its success, and because of its prominence in this country. The work must be cleaned, and this is done in the manner described for hot galvanising. The plant required for zincing 2,400 superficial feet per week of 54 working hours, with a thickness of 1 oz. per square foot, is as follows:

1 dynamo to give 1,000 amperes at 6 volts.
1 switchboard, measuring and regulating instruments.
1 galvanising tank, 6 ft. by 5 ft. by 3 ft.
1 pickling tank.
1 washing tank, 6 ft. by 5 ft. by 4 ft.
2 circular regenerating tanks, with fittings.
1 air compressor, for circulating electrolyte.
1 set of anode and cathode bars for zincing tank.

A longitudinal section of such an installation is shown in 5.

The Zinc Bath. Various zinc baths are used by different workers. That recommended by the inventor of the process consists of zinc sulphate 350 oz., sulphuric acid 1 oz., and water 10 gal. To obtain good bright deposits of zinc, the solution should be kept as free as possible from impurities, and if the electrolyte be too acid, a rough dark zinc coating will be given.



5. ELECTRO-GALVANISING PLANT

The work to be zinced is secured to dogs fixed to cross bars, which rest on copper strips attached to girders carrying the anodes, which are of lead instead of zinc. It was found that zinc anodes failed to keep the solution up to normal strength, disintegrating and causing a rough uneven deposit, and as the solution is regenerated by circulation between the electrolytic tank and the regenerating tank, lead anodes were tried with success.

Regenerating the Electrolyte. The accepted and economical method of regenerating the electrolyte is by adding to the regenerating tank zinc dust or tultz, preferably mixed with sand or coke, so as to form a filter bed and to prevent the dust from entering the depositing tank, where it would increase the electrical resistance. By the system of circulation caused by the apparatus, the electrolyte flows into the bottom of the depositing tank by gravity, the impoverished and therefore lighter liquid being drawn off over a sill at the end of the vat. When the articles are first placed in the bath, it is found well to use as high a current density as possible, and after a few minutes to reduce it to about 15 amperes per square foot.

Such, in brief, are the chief features of the process of electro-galvanising. On the score of economy, it has much to commend it for certain classes of work. When not in constant use, a large hot plant demands a very great expense to keep the mass of zinc in a molten condition, a necessity which does not exist with the electrolytic process, and this consideration is sometimes of paramount importance.

Sherardising. A process known as *sherardising* has been recently introduced, and it is properly a process of galvanising by quite a new method. An account of galvanising would be neither complete nor up-to-date if it did not take notice of it. By the process of sherardising, the articles to be rendered non-rusting are cleaned by pickling, polishing, or sand blasting, as already described, and are then placed in a closed iron receptacle, charged with zinc dust and heated to a temperature of 500° F. to 600° F., for a few hours, and allowed to cool. The drum is then opened and the iron articles removed, when they are found to be coated with a homogeneous zinc covering, depending in thickness upon the temperature and the duration of the treatment.

Sherardising Plant. The zinc used in the process of sherardising is the ordinary zinc dust of commerce, the market price of which is about 20s. per ton lower than zinc ingots, or *virgin speller*, as it is usually called. The process offers another important economy in that greasy articles can go straight into the sherardising drums without cleaning. The receptacle into which the zinc dust and the articles to be treated are placed is preferably airtight. The air is then exhausted, or if this be impracticable, carbon, in a fine state of subdivision, and to the proportion of 3 per cent. of the zinc dust, is added in order to prevent the formation of zinc oxide to an undesirable extent, as this dulls the appearance of the final coat. The usual type of receptacle employed is cylindrical, or polygonal in shape, arranged to be rotated or oscillated during the process of heating. The cylinder, when charged, is placed in the furnace, a cast-iron shell of suitable shape, with a series of Bunsen burners in its lower part. The receptacle is rotated or oscillated by hand power.

The coating given by the process of sherardising is brighter in its metallic lustre than that attained by electric deposition, although the spangled effect of hot galvanising cannot be imparted.

Doubtful Debts. Outstanding Liabilities. Suspense Accounts. General and Special Reserves. Investment of Fund. Secret Reserves.

RESERVES AND SINKING FUNDS

It has been assumed hitherto that all the expenses of the business of Smith & Jones are included in the trial balance shown on page 1327, and that as they have been taken into consideration in making up the profit and loss account, we have arrived at the correct amount of the net profit of the concern. It was, however, pointed out that the proprietor of a business with fixed assets must make allowance for decreases in their values, as shown in his books on account of the depreciation that is continually going on by reason of wear and tear. It will be seen from the balance-sheet already given that there are no fixed assets belonging to the business of Smith & Jones, and there is, therefore, no necessity to make allowance for depreciation, as the stock has been carefully taken and valued at not more than cost.

Book Debts. But there is an asset which requires examination before a definite statement can be made that all proper losses and expenses have been charged in the profit and loss account. That is the item of "Sundry Debtors," which in ordinary circumstances would have to be studied in detail in order that a conclusion might be formed as to whether any of the debtors are likely to fail to meet their obligations. In the present case the debtors are only three in number and the examination is a simple matter. In large undertakings, however, where there may be hundreds or thousands of debtors, the scrutiny of all the accounts and their consideration by the manager or proprietor would be a work of much labour and, even if carried out conscientiously, would probably end in a misleading result being obtained.

Reserve for Doubtful Debts. Another method is therefore adopted in order that proper provision may be made for the probability that some of the debtors will not pay the amount due from them. We have seen how a trader deals with an ascertained loss under this head by writing off the amount to the profit and loss account through a sub-account known as the Bad Debts Account. Past experience has told him that a certain proportion of his debtors fail to pay, and that although he has debts on his books amounting to £2,000, he cannot expect to receive every penny of that amount. An examination of his books for past years shows that the bad debts actually incurred and written off form a percentage at a fairly constant rate of the debts outstanding at the time of the last balance-sheet; and upon the figures of several years he is in a position to form an opinion as to how much should be allowed for probable loss on the debts now owing. He cannot point to any particular account as being bad; if he could he would at once write it off as a loss. But although he cannot do this, he knows that somewhere there are debtors who, from a variety of causes, will not discharge their indebtedness. To meet this contingency he decides to reserve an amount out of his apparent profits, and an allowance of what is deemed sufficient is accordingly made and debited to the profit and loss account. But the question then arises: Which account is to be credited? It would be both impracticable and incorrect to credit each debtor with a proportion.

Opening the Reserve Account. An account is therefore specially opened which is credited by the amount it has been decided to reserve. This account is generally entitled "Reserve for Bad and Doubtful Debts," and, as a rule, it is allowed to stand in the ledger as a credit balance throughout the year; bad debts which are definitely ascertained in the meantime being debited to the bad debts account. At the time of balancing the books the debit balance on the bad debts account is transferred to the reserve account, and a calculation is made to provide a fresh reserve against the debts now outstanding. In doing this, regard must be paid to any balance remaining on the reserve account after charging the bad debts, or for any excess of bad debts over the reserve set aside the previous year. These two contingencies are best illustrated by examples.

On 31st December, 1903, William Brown had book debts due to him amounting to £5,000, and he decided to make a reserve of 5 per cent. on that amount to meet possible losses. On 31st December, 1904, he found that his bad debts actually incurred during the year amounted to £200, while he had now book debts of the value of £5,500. He decided to set aside a reserve of 5 per cent. on this amount. During 1905 his losses by bad debts came to £300, while on 31st December of that year his debts outstanding were £6,000. He decided to make a reserve at the same rate as in the two previous years. The table given on the following page would be his reserve account.

A reserve of a similar nature is sometimes made for discounts which will have to be allowed to debtors. The process is exactly the same as in the case of bad debts, and need not therefore be explained in detail. The amount standing to the credit of the reserve account would, in the absence of special circumstances, be shown on the liabilities side of the balance-sheet, but it is the practice not to show a reserve for a specific purpose in this way but to deduct it from the particular asset in respect of which it has been created. For this reason

Dr. RESERVE FOR BAD AND DOUBTFUL DEBTS Cr.

1904 Dec. 31	To transfer from bad debts account	200	0	0	1903 Dec. 31	By profit and loss account (5% on £5,000)	250	0	0
					1904 Dec. 31	,, Do. (5% on £5,500) 275 Less Unexhausted balance 50	225	0	0
	,, Balance carried down..	275	0	0					
		475	0	0			475	0	0
1905 Dec. 31	,, Transfer from bad debts account	300	0	0	1905 Jan. 1	By Balance .. .. b/d	275	0	0
					Dec. 31	,, Profit and loss account (Excess of loss over reserve)	25	0	0
						,, Do. (5% on £6,000) ..	300	0	0
	,, Balance .. .. c/d	300	0	0					
		600	0	0			600	0	0
					1906 Jan. 1	By balance.. .. b/d	300	0	0

reserves for bad debts and discounts are deducted from the amount of the sundry debtors.

Outstanding Liabilities. There is yet a further point to be borne in mind in making up a profit and loss account. The books record only the transactions which have taken place, and we should find nothing in them of liabilities which become due automatically, such as rent, rates and taxes, until payments in respect of these matters were actually made. It is, therefore, very necessary at balancing time to make sure that all outstanding charges which affect the profit and loss account are taken into consideration before arriving at the final balance available for the proprietor. The majority of business houses have their books made up to the end of the months of March, June, September, or December; and it may safely be asserted that there is something unpaid in the nature of expenses, the liability for which has not yet been recorded.

An instance that immediately presents itself is rent, which becomes due on the usual quarter days, but which is frequently not paid for two or three weeks. The result would be that a trader making up his books to December 31st would find charged in his rent account only the amounts paid for Lady-Day, Midsummer, and Michaelmas quarters.

Taxes and Wages. Similarly, taxes are not payable until January 1st in each year; but as they cover the period from April 6th in one year to April 5th in the next, it is clear that any profit and loss account covering a year to December 31st must make allowance for the proportion of the charge falling against that year. The same considerations apply to rates which are either accruing or overdue but unpaid.

In a large manufacturing concern another item of considerable importance is wages. There are many undertakings in which the weekly wages bill considerably exceeds £1,000. The wages are made up to either Thursday or Friday evening and paid on the latter day or on Saturday. But if December 31st falls on Wednesday, the wages for the previous four or five days which have become due, and may amount to £1,000, are not recorded in the books, and must be taken into account in arriving at the true profits of the business for the period to December 31st.

Suspense Accounts. In order to bring these matters into the books the amounts outstanding are, if necessary, apportioned between the period for which the accounts are being prepared and the remainder of the time covered by the expense, whatever it may be, and a charge made in the profit and loss account in respect of the liability. In this case, as in that of the reserve for bad debts, it is not possible to credit each workman or rate collector with the amount due to him, so an account is opened and credited with the apportioned amount of the expenses. This account is shown on the liabilities side of the balance-sheet and is extinguished in the books as payments are made in the following period by being debited with the amounts so paid.

Payments in Advance. It sometimes happens that payments have been made during a financial year, part of which are properly chargeable against the following period. For example, insurance is usually paid once a year. In a large factory, fire and employers' liability insurance are not inconsiderable items, and if they are paid on September 29th by a manufacturer who has his accounts made up to December 31st, the year to the latter date will be bearing an unfair share of the burden if an adjustment is not made by which the following year will be made to bear that part of the expense of which it receives the benefit. In order to correct this a part of the expenditure—in the case above instanced, three-quarters of the premiums—will be carried forward on the debit side of an "Insurance Suspense Account," and will appear on the balance-sheet on the assets side under the head of "Insurance paid in advance." Likewise, any rates or other charges, part of which belong to the following year, should be apportioned and carried forward.

Reserve Fund. The reserve and suspense accounts explained so far have been in respect of specific matters outstanding at the time of balancing the books, which must be taken into consideration in arriving at the amount of the true net profit. There is, however, a reserve of a different nature which is

frequently seen in the balance-sheets of undertakings, principally limited companies. It is generally termed a *reserve fund*, and its treatment has afforded a fruitful theme for discussion among accountants. The great difference between the account representing the reserve fund and the kind of reserve account already dealt with is that it was necessary to create the latter by a charge against the profit and loss account, in order to ascertain the actual divisible profit available for the proprietors, while the former is brought into existence after that result has been obtained, and is, in fact, a part of the net profits. This difference is vital and the position may be summed up by saying that the reserve accounts in respect of specific assets are created to meet losses and expenses which it is known will be incurred in the future, while the reserve fund is a setting aside of net profits to meet possible losses of which the proprietor has no knowledge at the time but which, it is conceivable, may arise. The reserve fund usually found in balance-sheets is what is known as a *general reserve*—that is, it has been set aside out of profits, not for a specific purpose, but generally to meet contingencies. In the vast majority of cases there is no special investment of the fund, and care is seldom taken even to ensure that there are liquid assets readily available in case of necessity.

Investment of Reserve Fund. There is considerable difference of opinion whether a reserve fund, in order to deserve that name, should be separately invested and represented by specific assets, or if it is sufficient to merely make a book entry debiting the net profit and crediting a reserve fund account. The decision depends to some extent upon the nature of the business. In the case of banks, insurance companies, and similar undertakings, where a reserve fund is created largely for the purpose of meeting any shrinkage of value in the securities forming a considerable proportion of the assets, the desirability of specially investing the reserve is generally conceded; in trading concerns, however, other considerations apply, and the question is one that must be decided by the proprietors, having regard to the requirements of the particular business. One cause which is held to justify the non-investment of the fund is that the undertaking requires more working capital than would be left in the business if the profits were divided up to the hilt, or taken out of the business and separately invested; while another justification may be said to exist in the case of a business paying 4 or 5 per cent. on borrowed money, where it would be bad policy to invest part of the profits in Consols or other gilt-edged securities paying only 2½ to 3 per cent. Even if the reserve fund be left in the business, it is of course a source of strength, for it represents an excess of assets over liabilities and proprietors' capital; but to be *reserve* in the true sense of the term there should be liquid assets—*i.e.*, assets easily realisable—even if they are used in the business—readily available to meet an emergency.

The Two Views. The two points of view can be brought before the student in a simple manner by means of an illustration.

T. White takes a lease of some business premises for seven years, with the option of renewing for a further seven or fourteen years, and spends £420 upon altering them to suit his requirements. He does not charge this amount to his profit and loss account, for it is not an expense that can be fairly debited against the profits of a single year. If it is to be written off completely, it will be reasonable to spread the expense over the time during which he will occupy the premises. But here another consideration arises. He cannot yet tell whether he will wish to continue his tenancy after the expiration of the first seven years. If he decided to do so, he would still be able to enjoy the benefit of his improvements. The value of the premises will, naturally, be decreasing during the seven years by the ordinary process of wear and tear, but that is merely depreciation, and not the entire loss of the asset. There is, therefore, an element of uncertainty in the matter; and in order to make provision for the possibility of giving up his shop at the expiration of the first term of seven years, he has to devise means so that by the end of that period his books will not show him to be possessed of an asset which may then cease to exist, without providing for such a contingency.

He estimates that at the end of seven years the value of the premises will be reduced by wear and tear and effluxion of time to £280, and it will therefore be necessary to treat as an absolute loss £140 of the outlay. This he does by debiting profit and loss account with £20 depreciation each year and crediting the "Business Premises Account." By this means the premises will stand in the books at their actual value at the end of the time, subject to his deciding to retain possession.

But, as has already been said, he may give them up. In view of this fact he has, during the term of the lease, charged against his net profits such a sum as would equal the book value of the asset by the end of the seven years—*viz.*, £40 per annum. This amount he has carried to the credit of a reserve fund account, and if at the end of the first portion of his lease he surrenders the premises, the accumulated amount will be transferred to the business premises account, and so extinguish the asset in the books by the time it ceases to be valuable. As a result of these entries, the business premises and reserve fund accounts will appear in the books as shown on next page.

Under this method, nothing was done beyond making the book entries. White did not take £40 of his cash each year and invest it in Consols or other securities in order to have an amount available at the end of seven years towards acquiring other premises if he found his present shop unsuitable. But he might have considered such a course desirable, and in that case he would have opened a "Reserve Fund Investment Account," which would be debited each year with the amount invested in the particular

security he decided to purchase, cash being credited, of course, by the amount withdrawn. Dividends or interest accruing due on the investment, would be received in cash, and credited to the profit and loss account. At the end of seven years the investment account would have been debited with £280, and would represent the investment of the reserve fund account, which appears as a credit on the other side of the ledger. If the premises are given up, as assumed above, and the balance on the business premises account written off against the reserve fund account, the balance on the investment account will represent White's asset in place of the premises.

claimed are that exceptional losses, and losses on legitimate trading, may be borne without the profit and loss account of the year in which they are incurred having to suffer the whole loss. The better course is undoubtedly the gradual creation of a strong reserve fund by openly setting aside profits out of which any losses of the nature indicated could be met as occasion arose.

Sinking Funds. A sinking fund is a fund created by setting aside periodically fixed sums of money with the intention that at the end of a given time the instalments shall, with accumulations of interest, amount to a certain sum which will then be required for a specific purpose. The point which distinguishes a sinking fund

Dr. BUSINESS PREMISES ACCOUNT Cr.

1897 Jan. 1	To cash	420 0 0	1897 Dec. 31	By depreciation..	20 0 0
			1898 Dec. 31	,, Do.	20 0 0
			1899 to 1903	,, Do. (5 years)	100 0 0
			1903 Dec. 31	,, Reserve fund account..	280 0 0
		420 0 0			420 0 0

Dr. RESERVE FUND Cr.

1903 Dec. 31	To business premises account, amount transfered		1897 Dec. 31	By profit and loss account	40 0 0
			1898 Dec. 31	,, Do.	40 0 0
		280 0 0	1899 to 1903	,, Do. (5 years)	200 0 0
		280 0 0			280 0 0

Special Reserve. The reserve fund we have dealt with was in respect of a specific matter, and is known as a special reserve. Another example of a special reserve is that for equalising dividends in the case of a limited company where a portion of the net profit is kept in hand in order to be able to pay a fair rate of dividend to the proprietors—the shareholders—even in a bad trading year. This reserve is now not very frequently seen.

Secret Reserve. Another kind of reserve is known as a *secret reserve.* It is so-called from the fact that the balance-sheet does not disclose its existence, nor is there any account representing it in the books. It is created either by excessive charges being made in the profit and loss account for such matters as bad and doubtful debts, or by the overstating of liabilities, or the unnecessary writing down of assets. The practice is favoured by companies of the highest standing, and, while it has its advantages, it also possesses undoubted drawbacks. The very existence of a secret reserve, and the manner of creating it, necessitate the withholding of material facts from the shareholders, while the system opens the door to fraudulent practices on the part of dishonest managers, who are enabled to conceal losses in speculation by writing up values of assets previously written down. The advantages

from a reserve fund is that while the latter may be represented by assets remaining in the business and not specially appropriated to the fund, the former must always consist of cash, or the equivalent of cash, invested outside the business. The usual purposes for which sinking funds are created are (1) to provide for the repayment of borrowed money at the end of a fixed period, and (2) to provide a fund to renew an asset of a wasting nature, such as machinery or a lease.

It has been seen how necessary it is to write down fixed assets in the books to their actual values by charging depreciation on account of wear and tear and other matters ; but in many cases this is not sufficient. Unless provision is made gradually, a manufacturer is faced with the situation that his machinery is worn out and must be replaced, and although he has allowed for depreciation yearly before arriving at his profits, he has taken no steps to accumulate a fund out of which he could purchase new machinery. His capital is all locked up in his business, and cannot be withdrawn without damage. In order to obviate this difficulty it would be necessary for him to create a sinking fund, so that when the old machinery is unusable he can arrange for the installation of a new set without financially dislocating his business.

Borrowed Money. The repayment of borrowed money is a factor which has to be provided for by a limited company which has issued debentures. The characteristics of debentures will be explained later, when dealing with the accounts of limited companies, and as the student may not be aware of the different circumstances under which they are issued, the case of a sinking fund to replace a specific asset will be dealt with now rather than one relating to debentures.

The first step to take is to decide, either by calculation or by reference to published tables, the amount necessary to be set aside and invested each year, so that, allowing for interest on the investment at a certain rate, the sum accumulated will reach the amount required by the time it is needed. Having fixed the amount, the process is the same, with one exception, as that adopted with regard to the investment of the reserve fund. The one exception is that interest on the investment, instead of being credited to profit and loss account, is added to the amount of the investment, which is therefore accumulating at compound interest during the building up of the fund.

Sinking Fund for Wasting Asset. We will suppose that a system of machinery has been installed in a factory at a cost of £5,000, and that it is anticipated that its working power will be exhausted, notwithstanding repairs in the meantime, at the end of 20 years. It is intended that the business shall be continued after that time, and it will therefore be necessary to put in a new lot of machinery when the old is worn out. In the ordinary course of events there will not be a surplus of £5,000 in the bank above the current requirements of the business, and the proprietor decides to raise a fund during the life of the present machinery out of which the new machinery can be purchased when it is required. It is found that the amount required to be set aside each year in order to do this, after allowing for accumulations of interest in the meantime at 3 per cent., is £186 1s. 7d.

The entries necessary in the books will be, first, a debit to profit and loss account, and a credit to the machinery account, of the instalment. A corresponding amount of cash will then be taken from the bank and invested in the purchase of the stock chosen for the purpose of the sinking fund investment. This will necessitate a debit to the sinking fund investment account and a credit to the bank.

Dr. SINKING FUND INVESTMENT ACCOUNT FOR MACHINERY Cr.

		£	s.	d.			£	s.	d.
1900 Dec. 31	To cash	186	1	7					
1901 Dec. 31	,, Interest (1 year @ 3 %)	5	11	7					
,,	,, Cash	186	1	7					
		377	14	9					
1902 Dec. 31	,, Interest (1 year @ 3%)	11	6	7					
,,	,, Cash	186	1	7					
		575	2	11					
1903 Dec. 31	,, Interest (1 year @ 3%)	17	5	1					

Dr. MACHINERY ACCOUNT Cr.

		£	s.	d.			£	s.	d.
1900 Jan. 1	To cash	5000	0	0	1900 Dec. 31	By profit and loss account	186	1	7
					1901 Dec. 31	,, Interest on investment	5	11	7
					,,	,, Profit and loss account	186	1	7
							377	14	9
					1902 Dec. 31	,, Interest on investment	11	6	7
					,,	,, Profit and loss account	186	1	7
							575	2	11
					1903 Dec. 31	,, Interest on Investment	17	5	1

At the end of the year, when the interest on the stock has become due, the investment account is debited with the amount, which is allowed to remain, and itself earn interest, while the machinery account is credited. At the same time another instalment of £186 1s. 7d. is taken out of cash and invested, entries being made similar in all respects to those at the beginning. The accompanying tables show the entries on the investment and machinery accounts for the first three years.

This process is continued each year until, at the end of 20 years, the fund has grown to the amount required—*viz.* £5,000. The investment is then sold, and the proceeds used for purchasing the new machinery.

J. F. G. PRICE

A special Dictionary explaining Commercial Terms and Phrases appears at the end of the Self-Educator

Capital. Dividends. Consols. Preference and Debenture Stocks. Brokerage. Stock-Jobbing. Problems.

STOCKS AND SHARES

132. The cash necessary to carry on a business is called its *Capital.*

In some businesses, such as railways, waterworks, gasworks, etc., the capital required is too large to be supplied by one person. Let us suppose a new railway is to be made. The originators, or *Promoters,* of the scheme, issue a *Prospectus* explaining it, and stating the Capital required. This capital is divided into *Shares* of some fixed amount, such as £100, £20, £1, and members of the general public are asked to *apply* for shares. If enough applications are received to enable the promoters to go on with the undertaking, they *allot* shares to the applicants, and thus obtain the capital required. The persons who hold the shares are called the *Company.* The profits of the company in each year are divided among the shareholders in proportion to the face value of their shares. The money thus divided is called the *Dividend.*

A shareholder who wishes to retire from the company cannot obtain from it the money which he subscribed, but he may sell his shares. The amount he obtains for them will probably not be the same as the amount he originally subscribed: it will depend chiefly on the profits which the company makes.

133. The capital of a company is often called *Stock.* When the capital is called *stock,* a shareholder may sell *any quantity,* excluding fractions of a penny. For instance, a person holding £100 stock, may, if he pleases, sell £42 4s. 6d. stock.

But, if the capital is called *shares* he may only sell a complete number of shares. He cannot sell *part* of a share.

134. It is of the greatest importance the student should understand that "£100 stock" means "that amount of stock for which £100 was originally subscribed." It does *not* mean "that amount of stock which will *sell* for £100."

If £100 stock will sell for £100 cash, it is said to be *at par.* If it sells for *more* than £100 cash, say £108, it is said to be *at a premium of 8 per cent.,* or 8 *above par.* If it sells for *less* than £100 cash, say £97, it is said to be *at a discount of 3 per cent.,* or 3 *below par.*

135. In the case of public companies, we have seen that the dividend varies with the profits of the company. There is another sort of stock in which the dividend obtained from £100 stock is always the same. The Government of a country borrows money, for war expenses, and other purposes. The corporations of towns borrow money. Public companies borrow. In all these cases, a fixed interest is paid per annum on each £100 stock.

A great portion of the British National Debt consists of the "Consolidated Annuities," abbreviated into "Consols," so called, because they were formed by consolidating several debts, contracted under various conditions, into one stock.

When a company borrows money at a fixed rate, it is often arranged that the interest on this new stock shall be paid before any dividend is paid on the original stock. The new stock is called *Preference* stock, and the old is called *Ordinary. Debenture* stock also receives a dividend before ordinary stock.

136. Stocks and shares are usually bought and sold through an agent called a *Stockbroker.* The charge which a broker makes for his services is called *brokerage.* In the case of Government stocks the brokerage is usually "$\frac{1}{8}$ per cent.," *i.e.,* 2s. 6d. on each £100 stock. The broker acts as the agent between the buyer or seller and the *Stock-jobber,* who deals in stocks and shares.

As an example, consider the following: On Monday, November 20th, Consols were quoted as "$88\frac{7}{8}$ to 89." This means that the jobber is ready to buy £100 of Consols for £$88\frac{7}{8}$ or to sell £100 of Consols for £89. Suppose then, a person, A, wishes to dispose of £100 Consols. A goes to his broker. The broker seeks out a jobber, who pays £$88\frac{7}{8}$ for the stock. The broker deducts £$\frac{1}{8}$, and hands over the remaining £$88\frac{3}{4}$ to A. Next, if another person, B, wishes to buy £100 Consols, he goes to *his* broker. B's broker then finds the jobber, who now receives £89 for the stock; but B pays £$89\frac{1}{8}$ for it, since the broker requires £$\frac{1}{8}$.

A's Broker receives £$\frac{1}{8}$ from A		B's Broker receives £$\frac{1}{8}$ from B
	Jobber	B
Receives £$88\frac{7}{8}$ from jobber, and pays broker £$\frac{1}{8}$. Thus clears £$88\frac{3}{4}$	Pays A £$88\frac{7}{8}$. Receives from B £89	Pays £89 to jobber and £$\frac{1}{8}$ to broker. Pays £$89\frac{1}{8}$ in all.

Hence, in examples where brokerage has to be reckoned, the brokerage is added to the price when stock is bought, and subtracted when stock is sold.

It will be noticed that the broker's profit is certain. The jobber's profit, of course, depends on the difference between the buying price and selling price. Moreover, the jobber does not always manage to sell stock immediately after buying it, as was assumed in the above illustration.

137. We shall now work out various examples in stocks and shares. All questions in stocks

depend on the principles of Proportion. The student ought to find no difficulties if he remembers that:

(1) £ s. d. *in* a company is *Stock*.
(2) £ s. d. to be *sold out* is *Stock*.
(3) £ s. d. to be *invested* is *Cash*.
(4) Brokerage is not reckoned unless specially mentioned in the question.

Example 1. I invest £4653 in $2\frac{1}{2}$ per cent. Consols at 94. How much stock do I get, and what is my income?

Here, we are told that £94 will buy £100 stock, and we have to find how much stock £4653 will buy.

$\therefore$ £94 : £4653 :: £100 stock : Required stock.

$$\text{Required stock} = £\frac{100 \times 4653}{94} = \underline{£4950 \ \textit{Ans.}}$$

Again, we know that £100 stock gives an income of £$2\frac{1}{2}$. We have to find what income £4950 stock will give.

$\therefore$ £100 : £4950 :: £$2\frac{1}{2}$: Income.

$$\therefore \text{Income} = £\frac{4950 \times 5}{100 \times 2} = \underline{£123 \ 15s. \ \textit{Ans.}}$$

Or, in finding the income, we may work with cash instead of stock. For we know that by investing £94 an income of £$2\frac{1}{2}$ is obtained, and we are required to find what income is obtained by investing £4653.

Example 2. If I invest in 6 per cent. stock at 140, what percentage do I get on my money?

We have to find what income £100 will produce, if £140 gives an income of £6.

Hence,

£140 : £100 :: £6 : Required percentage.

$$\therefore \text{Percentage} = \frac{600}{140} = \underline{4\tfrac{2}{7} \ \textit{Ans.}}$$

Example 3. Which is the better investment, 3 per cents. at 98, or $3\frac{1}{2}$ per cents. at 115?

We may either, as in Example 2, find the actual percentage in each case; or, we may proceed as follows:

The prices are £98 and £115.

$\therefore$ Invest 98 × 115 in each stock.

The income from 3 per cent. is then

$$115 \times £3 = £345.$$

The income from $3\frac{1}{2}$ per cent. is

$$98 \times £3\tfrac{1}{2} = £343.$$

Therefore, the 3 per cent. stock is the better investment.

Example 4. A man sells out £5,000 from the $2\frac{1}{2}$ per cent. Consols at $85\frac{1}{8}$ (brokerage $\frac{1}{8}$) and invests the proceeds in $6\frac{1}{2}$ per cent. railway shares at $165\frac{1}{2}$ (brokerage $\frac{1}{4}$). Find the change in his income.

His income from Consols = 50 × £$2\frac{1}{2}$ = £125.

He sells £100 Consols for $85\frac{1}{8} - \frac{1}{8}$, *i.e.*, £85.

Therefore, he sells £5,000 Consols for 50 × £85.

Next, to obtain £$6\frac{1}{2}$ income from railway shares, he has to invest £$(165\frac{1}{2} + \frac{1}{4})$, *i.e.*, £$165\frac{3}{4}$. We find, by proportion, what income he will get by investing 50 × £85.

Thus,

$165\frac{3}{4}$: 50 × 85 :: £$6\frac{1}{2}$: Income.

Hence, his new income

$$= £\frac{6\frac{1}{2} \times 50 \times 85}{165\frac{3}{4}} = \frac{13 \times 50 \times 85 \times 4}{2 \times 663}$$

$$= £\frac{500}{3} = £166 \ 13s. \ 4d.$$

Therefore, the new investment increases his income by £166 13s. 4d. − £125 = £41 13s. 4d. *Ans.*

Note, that in examples of this sort, it is not necessary to find *the amount of stock* he obtains by the new investment.

Example 5. A man invested his money in railway stock which yielded a dividend of $6\frac{1}{2}$ per cent. the first year, and he paid 1s. in the £ income-tax. The next year the dividend was 6 per cent., and the income-tax was 10d. His net income was thus reduced by £119. How much stock had he?

Income-tax at 1s. on £$6\frac{1}{2}$ = $6\frac{1}{2}$s.

$\therefore$ In the first year, each £100 stock gives a net income of £6 10s. − 6s. 6d. = £6 3s. 6d.

Income-tax at 10d. on £6 = 5s.

$\therefore$ In the second year, each £100 stock gives a net income of £6 − 5s. = £5 15s.

Hence, his income from each £100 stock is reduced by £6 3s. 6d. − £5 15s., or 8s. 6d.

But the total reduction is £119, and we find by proportion what amount of stock this represents.

Thus,

8s. 6d. : £119 :: £100 stock : Required amount

Whence, amount of stock

$$= £\frac{100 \times 119 \times 2 \times 20}{17} = \underline{£28000 \ \textit{Ans.}}$$

Example 6. A man invests £22000, partly in 3 per cent. stock at 88, and partly in $4\frac{1}{2}$ per cent. stock at 110. He finds that on the whole he gets $3\frac{1}{2}$ per cent. for his money. How much is invested in the $4\frac{1}{2}$ per cents?

His income = 220 × £$3\frac{1}{2}$ = £770.

If all his money was invested in the 3 per cents. his income would be

$$£\frac{22000 \times 3}{88} = £750.$$

This is £20 less than his actual income.

The L.C.M. of 88 and 110 is 440. If £440 is invested in the 3 per cents. it gives an income of 5 × £3 = £15. If £440 is invested in the $4\frac{1}{2}$ per cents., it gives an income of 4 × £$4\frac{1}{2}$ = £18. That is, by investing £440 in the $4\frac{1}{2}$ per cents. instead of in the 3 per cents., he increases his income by £18 − £15 = £3. We have only to find how much he must transfer to the $4\frac{1}{2}$ per cents. to increase his income by £20.

Thus,

3 : 20 :: £440 : Required Ans.

$\therefore$ Amount invested in $4\frac{1}{2}$ per cents.

$$= £\frac{440 \times 20}{3} = £\frac{8800}{3}$$

$$= \underline{£2933 \ 6s. \ 8d. \ \textit{Ans.}}$$

NOTE. If we had been required to find the amount of *stock* in the 4½ per cents.? we should simply have had to use £400 stock, instead of £440 cash, for the third term of the proportion.

EXAMPLES 17

1. How much must be invested in 4¾ per cent. stock at 102 to obtain an income of £380 ?

2. A man sells out £9400 of 2½ per cent. Consols at 90, and invests the proceeds in a 4 per cent. stock. He thus increases his income by £5. What was the price of the 4 per cents. ?

3. How much must be invested in 3½ per cent. stock at 115⅜ (brokerage ⅛) to give an income equal to that obtained from £5775 stock in 3 per cents. at 99 ?

4. A man invests in a 5 per cent. stock. After paying an income tax of 1s. in the £, he finds he gets 3¾ per cent. on his money. At what price did he buy the stock ?

5. A man invests half his capital in 3¾ per cent. stock at 90, and the rest in 4½ per cents. He obtains the same income from each investment. What is the price of the 4½ per cents. ?

6. By investing a certain sum in the 3½ per cents. at 98, my annual income is £15 more than if I had invested in 3 per cents. at 90. What sum did I invest ?

7. A person has £8225 in a 3½ per cent. stock. He sells out as much of it, at 102, as will produce £4131, and invests the proceeds in 5¼ per cents. at 119. Find the change in his income.

8. A man invests £2500, some of it in 3¼ per cents. at 103⅓, and the rest in 4 per cents. at 140. On the whole, he gets 3 per cent. interest on his money. How much of each stock does he buy ?

Answers to Arithmetic

EXAMPLES 16

1. £441 12s. 6d.

2. Interest = £980 − £875 = £105. Interest on £875 for 3 years at 1 per cent. = £26·25. ∴ Required rate = £105 ÷ £26¼ = 4 per cent.

3. Interest on £100 for 8 years at 4½ per cent. = £36. Hence, the proportion is £36 : £183 3s. :: £100 : Required sum. This gives £508 15s. *Ans.*

4. At 4 per cent., the interest on £100 will have amounted to £100 in 100 ÷ 4 = 25 years *Ans.*

5. £1691 4s. 10d.

6. See Art. 126. Then, working in a similar way to Art. 125, we get the required interest = £4 15s. 11·98d. = £4 16s.

7. £212 10s.

8. By method of Art. 128, Ex. 2, the present worth is found to be £1250. Hence, the true discount is £1447 0s. 7½d. − £1250 = £197 0s. 7½d.

9. See Art 131. Amount of bill = £816 13s. 4d.

EXAMPLES 17.

1. 4¾ : 380 :: £102 : Reqd. Amnt. = £8160 *Ans.*

2. His income from Consols = 94 × £2½ = £235. Therefore, income from 4 per cents. = £235 + £5 = £240. Amount obtained from sale of Consols = 94 × £90 = £8460. But, £240 income from 4 per cents. requires £(240 × 100 ÷ 4) stock = £6000 stock. Hence £6000 stock costs £8460. Therefore £100 stock costs £8460 ÷ 60 = £141 *Ans.*

3. Income from £5775 in the 3 per cents. = 57¾ × £3 = £173¼. (The *price* of the stock, £99, does not affect the question.) Price of the 3½ per cents. = 115⅜ + ⅛ = 115½. Therefore, since 115½ must be invested to produce £3½ income, the amount which must be invested to produce £173¼ is $£\frac{173\frac{1}{4} \times 115\frac{1}{2}}{3\frac{1}{2}}$ = £5717 5s. *Ans.*

4. Net income from each £100 stock = £5 − 5s. = £4¾. To obtain an income of £3¾ he has to invest £100. The price of the stock is the amount he has to invest to obtain an income of £4¾. Hence, 3¾ : 4¾ :: £100 : Required price. Therefore, price = $\frac{100 \times 4\frac{3}{4}}{3\frac{3}{4}}$ = 126⅔ *Ans.*

5. L.C.M. of 3¾ and 4½, *i.e.*, of $\frac{15}{4}$ and $\frac{18}{4}$, is $\frac{90}{4}$. Now, $\frac{90}{4}$ = 6 × 3¾, or 5 × 4½. Thus, £600 stock in 3¾ per cents. produces the same income as £500 stock in 4½ per cents. But £600 of first costs 6 × £90 = £540. Therefore £500 of second stock costs £540, so that price of stock = £540 ÷ 5 = £108 *Ans.*

6. The income from £90 × 98 invested in 3½ per cents. at 98 = 90 × £3½ = £315. Similarly, the income from 90 × 98 invested in the other stock = 98 × £3 = £294. Thus, when 90 × 98 is invested, the income is £21 greater in the first case. If, then, the income is £15 greater, the amount invested is $\frac{£90 \times 98 \times 15}{21}$ = £6300. *Ans.*

7. The change in income is that due to investing £4131 in 5¼ per cents. at 119 instead of in 3½ per cents. at 102. The income in the first of these cases is $£\frac{4131 \times 5\frac{1}{4}}{119}$ = £182¼. In the second case it is $£\frac{4131 \times 3\frac{1}{2}}{102}$ = £141¾. Hence he increases his total income by £182¼ − £141¾ = £40 10s. *Ans.*

8. His income = 25 × £3 = £75. If all his money was invested in the 3¼ per cents., his income would be $£\frac{2500 \times 3\frac{1}{4}}{103\frac{1}{3}}$ = £78$\frac{39}{62}$. This is £3$\frac{39}{62}$ greater than his actual income. Next, the L.C.M. of £103⅓ and £140 is found to be £4340. This sum, invested in 3¼ per cents. gives an income of 42 × £3¼ = £136½. The same sum invested in 4 per cents. gives 31 × £4 = £124. Thus, by investing £4340 in 4 per cents. instead of 3¼ per cents., the income would be reduced by £12½. We have to find how much must be invested in 4 per cents. to reduce the income by £3$\frac{39}{62}$. Thus, 12½ : 3$\frac{39}{62}$ :: £4340 : Required amount.

∴ Required amount = $£\frac{4340 \times 225 \times 2}{62 \times 25}$ = £1260.

Hence, £1260 is invested in 4 per cents. at 140, giving £900 stock; and the remaining £1240 is invested in 3¼ per cents. at 103⅓, giving £1200 stock. The answer is, therefore, £900 of 4 per cents. and £1200 of 3¼ per cents.

H. J. ALLPORT

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